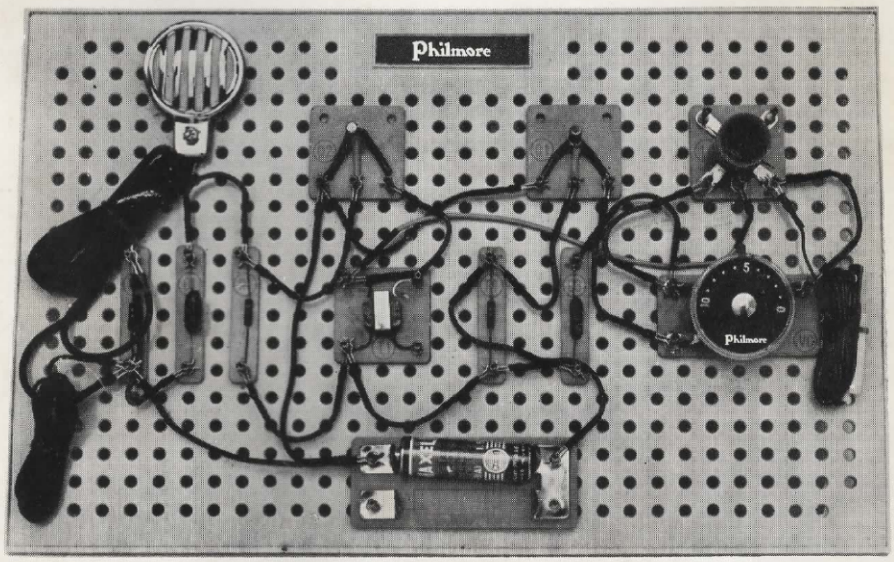
Philmore

ASSEMBLY MANUAL
FOR KIT-9
EDUCATIONAL ELECTRONIC KIT

USING SOLAR CELL

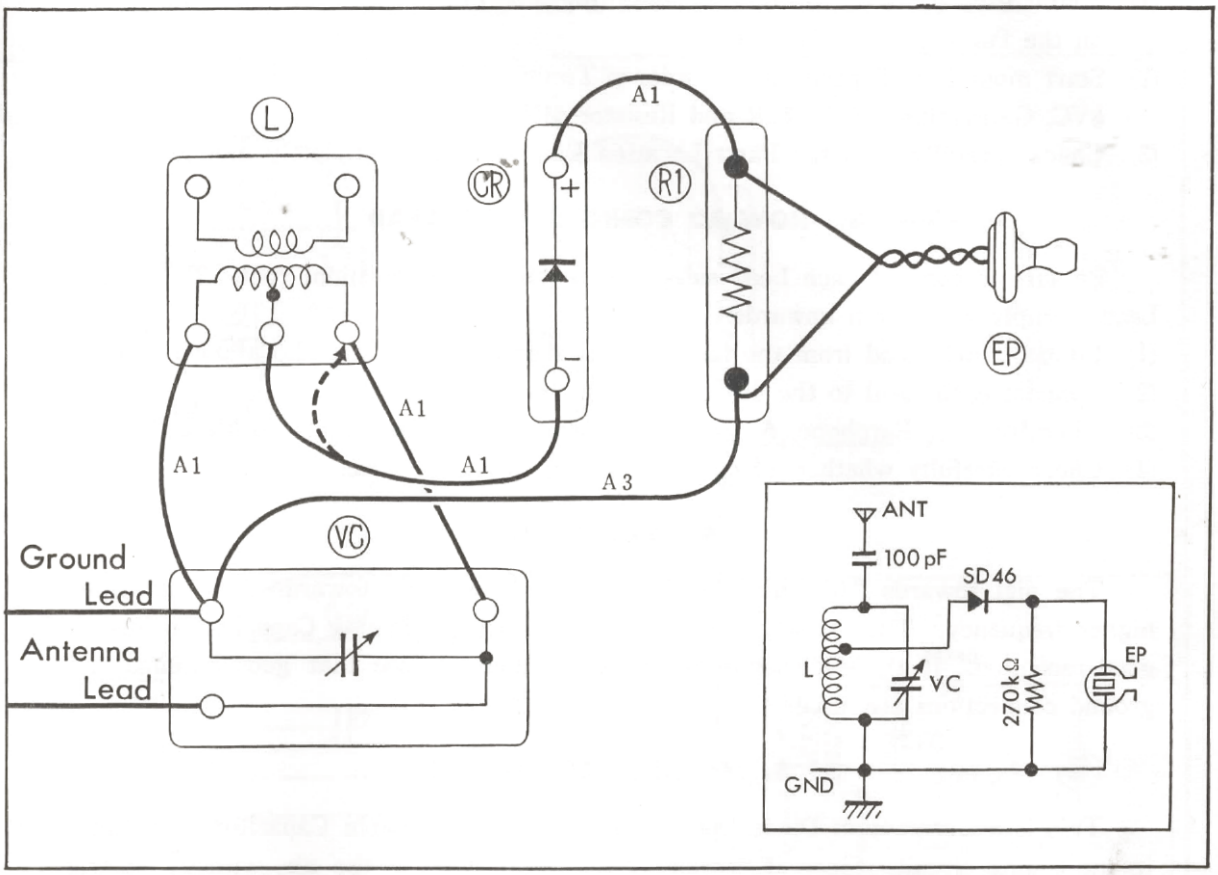
20 different circuits can be built without tools. Also no soldering required.



COMPLETE PARTS LIST FOR PROJECTS FROM #1 TO #20

Names of Parts	Specifications	Qty.	Quantities to be used for each project																			
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Circuit Mounting Board	200m/m×320m/m	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Tuning Coil #L	L.....340μH	1	1	1	1	1	1	1			1	1	1		1			1	1			
Variable Tuning Capacitor #VC	MAX.....260PF	1	1	1	1	1	1	1			1	1	1	1	1			1	1			
Transistor #Q1	2SA156 or equivalent	1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Transistor #Q2	2SB117 or equivalent	1									1	1	1	1			1	1	1	1	1	1
Germanium Diode #CR	SD46 or equivalent	1	1	1		1	1					1	1	1								1
Resistor #R1	270KΩ ¼W	3	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	2	3	2	2	2
Resistor #R2	5.6KΩ ¼W	2				1	1		1	1	1	1	1	1		1	2			1	2	1
Resistor #R3	1.0KΩ ⅙W	1													1	1						
Capacitor #C1	0.1μF 50WV	2			1	1	2	1	2	2	1	2	2	2	1	2		1	1	2	2	2
Capacitor #C2	0.01μF 100WV	1															1	1				1
Capacitor #C3	0.005μF 400WV	1															1	1	1			1
Transformer #T1	10 : 1	1									1	1	1	1		1	1	1	1	1		1
Volume Control #VR	500KΩ	1										1		1			1			1		1
Code Sending Key #K		1													1	1	1	1				
Microphone #M	Crystal type	1																	1	1		
Battery Holder #BH		1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dry Battery	UM-3 1.5V or equiv.	1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Earphone #EP	Crystal type	1	1	1	1	1	1	1			1	1	1	1		1	1			1		1
Antenna Lead	2m	1	1	1	1	1	1	1			1	1	1	1	1			1	1			
Ground Lead	2m	1	1	1	1	1	1	1			1	1	1	1	1			1	1			
Short Wave Coil #LS	3.5MC～8.0MC	1												1								
Connecting Lead #A1	Blue	13	4	5	6	8	9	6	4	4	11	13	13	11	6	6	9	13	13	11	10	13
Connecting Lead #A2	Brown	3			1	1	1	1	2	2	1	2	1	3	2	2	2	3	2	3	1	3
Connecting Lead #A3	Green	3	1	1	1	2	2	1	1	1	2	3	3	2	2	2	3	3	1	1	1	3
Connecting Lead #A4	Grey	3										2		2	1	1	2	2	1	1	1	
Solar Cell	Selenium 0.5V	1			○	○	○	○	○	○	○	○	○			○						

PROJECT #1 for Assembling Germanium Diode Radio



1. PREPARATION

Prepare the following 10 different parts only out of the entire parts included in this KIT:

Circuit Mounting Board	1 pc.
Antenna Lead	1 〃
Tuning Coil #L	1 〃
Variable Tuning Capacitor #VC	1 〃
Germanium Diode #CR	1 〃
Resistor #R1	1 〃
Crystal Earphone #EP	1 〃
Ground Lead	1 〃
Connecting Lead #A1 (Blue)	4 pcs.
Connecting Lead #A3 (Green)	1 pc.

2. HOW TO ASSEMBLE

(1) Mount each parts on the Circuit Mounting Board from the left hand as shown on the Parts Location Diagram.
(2) Start mounting all parts in the order of Tuning Coil #L, Variable Tuning Capacitor #VC, Germanium Diode #CR and Resistor #R1.
(3) Check carefully with the Parts Location Diagram after completely mounted.

3. HOW TO CONNECT EACH LEAD

Be sure to connect each Lead sidewards to the proper terminal root. To remove Leads, simply slide them upwards.

(1) Connect each Lead from the left parts as shown on the Parts Location Diagram.
(2) Connect each Lead to the proper terminal root tightly.
(3) Then, connect Earphone, Antenna & Ground Leads to the right position.
(4) Check carefully whether all connections are correctly made.

4. RECEPTION

The dial towards "0" indicates lower frequency while towards "10" indicates higher frequency. Tune slowly the dial knob of Variable Tuning Capacitor to have a good reception. If this receiver does not work, check to see that good antenna and ground connections are used.

5. CIRCUIT DESCRIPTION

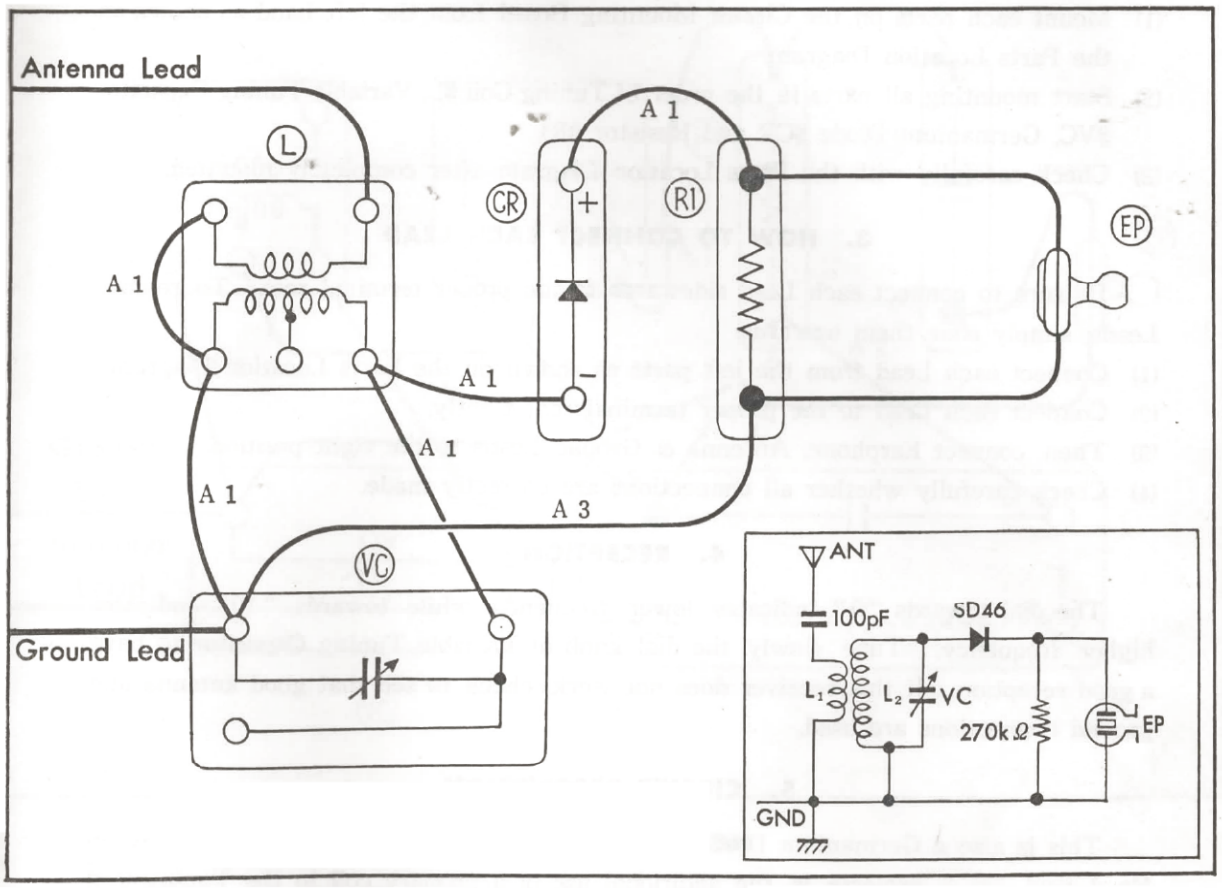
This is a Germanium Diode Detector Radio with a Variable Capacitor as a tuner in the tuning circuit. Since it works by the radio wave in the air, without electric source, it is advisable to use a good long antenna and a good ground connection. Near the broadcasting stations, good reception can be had by extending the Antenna out into the open air or connecting the Antenna plug to the telephone dial. However, in ferro-concrete buildings or in places remote from the broadcasting stations, a good outdoor antenna and a ground wire connected to ground are necessary because of the weak signal waves.

There are different kinds of radio waves crowded in the air, from low frequency to ultra-high frequency, which all flow into the antenna. A wanted wave in the broadcasting band can be tuned through the function of the Tuning Coil and Variable Tuning Capacitor by dialing. The selected wave will then be detected by the Germanium Diode and converted into audio current for vibrating the element of earphone to produce sound.

TECHNICAL TERMS

Variable Tuning Capacitor: A Capacitor whose capacitance can be varied by moving one set of metal plates with respect to another.

PROJECT #2 for Assembling Germanium Diode Radio



1. PREPARATION

Prepare the following 10 different parts only out of the entire parts included in this KIT:

Circuit Mounting Board	1 pc.
Tuning Coil #L	1 〃
Antenna Lead	1 〃
Variable Tuning Capacitor #VC	1 〃
Germanium Diode #CR	1 〃
Resistor #R1	1 〃
Crystal Earphone #EP	1 〃
Ground Lead	1 〃
Connecting Lead #A1 (Blue)	5 pcs.
Connecting Lead #A3 (Green)	1 pc.

2. HOW TO ASSEMBLE

(1) Mount each parts on the Circuit Mounting Board from the left hand as shown on the Parts Location Diagram.
(2) Start mounting all parts in the order of Tuning Coil #L, Variable Tuning Capacitor #VC, Germanium Diode #CR and Resistor #R1
(3) Check carefully with the Parts Location Diagram after completely mounted.

3. HOW TO CONNECT EACH LEAD

Be sure to connect each Lead sidewards to the proper terminal root. To remove Leads, simply slide them upwards.

(1) Connect each Lead from the left parts as shown on the Parts Location Diagram.
(2) Connect each Lead to the proper terminal root tightly.
(3) Then, connect Earphone, Antenna & Ground Leads to the right position.
(4) Check carefully whether all connections are correctly made.

4. RECEPTION

The dial towards "0" indicates lower frequency while towards "10" indicates higher frequency. Tune slowly the dial knob of Variable Tuning Capacitor to have a good reception. If this receiver does not work, check to see that good antenna and ground connections are used.

5. CIRCUIT DESCRIPTION

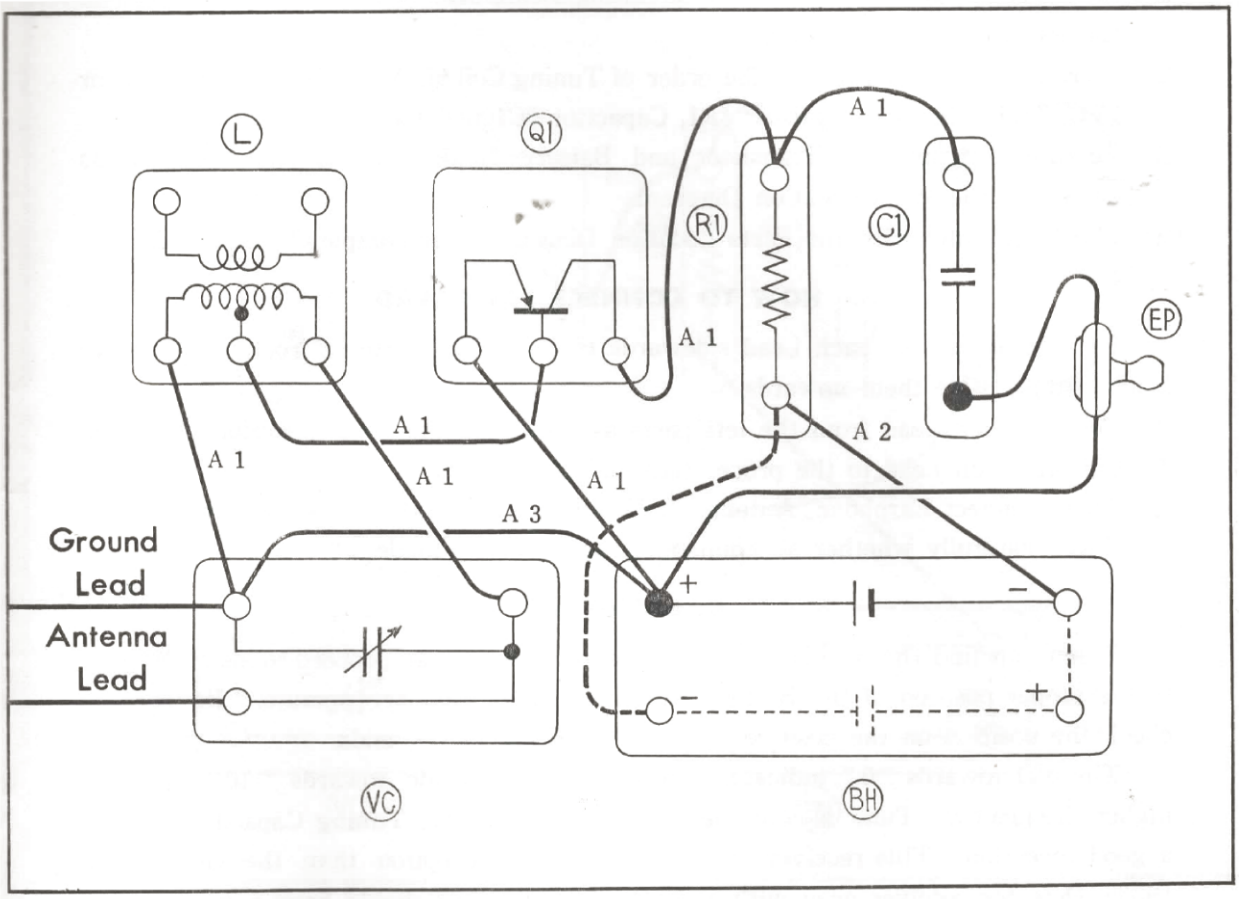
This is also a Germanium Diode Detector Radio. The only difference between No. 1 and No. 2 projects is the additional use of a primary coil in the Tuning Coil (L1). In Project No. 1, Antenna Lead is connected to the secondary coil, but in Project No. 2 Antenna Lead is connected to the primary coil. In other words, the radio wave flowing from the antenna to the ground will induce micro voltage in the primary coil which will in turn induce voltage in the secondary coil. This will then be detected by the Germanium Diode to become audio current (low frequency). Because the antenna lead is separated from the secondary coil of the Tuning Coil, the frequency will not deviate and will give less "Jamming"

Antenna: Derived from a Greek word meaning "horn of an insect" is now a radio term of a device (usually a lengthy wire of a radio) from where signals are received.

Tuning: Variation of the capacity of inductance in an alternating current circuit to cause resonance at a certain frequency.

Condenser: A device consisted of two conductors separated by an insulating material is capable of holding an electrical charge.

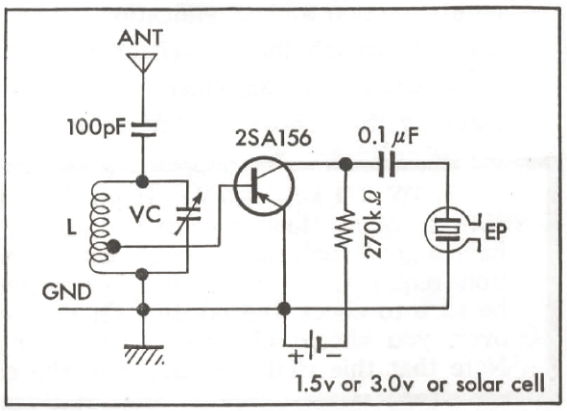
PROJECT #3 for Assembling 1-Transistor Radio



1. PREPARATION

Prepare the following 14 different parts only out of the entire parts included in this KIT:

Circuit Mounting Board	1 pc.
Tuning Coil #L	1 〃
Antenna Lead	1 〃
Variable Tuning Capacitor #VC	1 〃
Transistor #Q1	1 〃
Resistor #R1	1 〃
Capacitor #C1	1 〃
Crystal Earphone #EP	1 〃
Battery Holder #BH	1 〃
Dry Battery 1.5V	1 〃
Ground Lead	1 〃
Cannecting Lead #A1 (Blue)	6 pcs.
Connecting Lead #A2 (Brown)	1 pc.
Connecting Lead #A3 (Green)	1 〃



2. HOW TO ASSEMBLE

(1) Mount each parts on the Circuit Mounting Board from the left hand as shown on the Parts Location Diagram.

(2) Start mounting all parts in the order of Tuning Coil #L, Variable Tuning Capacitor #VC, Transister #Q1, Resistor #R1, Capacitor #C1 and Battery Holder #BH.

(3) Be sure to mount the Transistor and Battery Holder in the right position as shown on the Parts Location Diagram.

(4) Check carefully with the Parts Location Diagram after completely mounted.

3. HOW TO CONNECT EACH LEAD

Be sure to connect each Lead sidewards to the proper terminal root. To remove Leads, simply slide them upwards.

(1) Connect each Lead from the left parts as shown on the Parts Location Diagram.

(2) Connect each Lead to the proper terminal root tightly.

(3) Then, connect Earphone, Antenna & Ground Leads to the right position.

(4) Check carefully whether all connections as correctly made.

4. RECEPTION

When you find the wiring work done properly, you may proceed to install Battery to the proper position of the Battery Holder to make this set operate. Be sure to check the position on the positive (+) and the negative (−) ends.

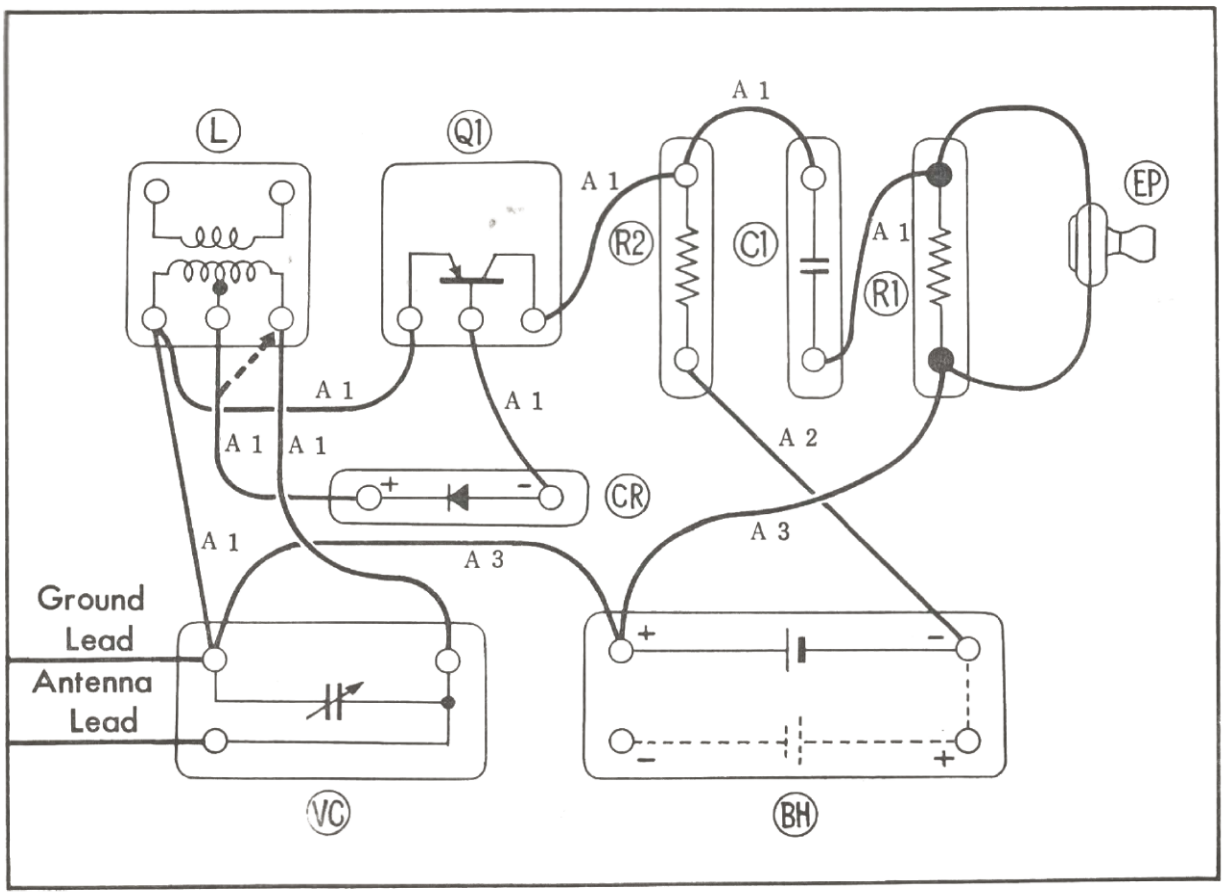
The dial towards "0" indicates lower frequency while towards "10" indicates higher frequency. Tune slowly the dial knob of Variable Tuning Capacitor to have a good reception. This receiver can have a better reception than the Germanium Diode Detector receiver even with a shorter antenna, but should have a good ground lead connected to ground.

5. CIRCUIT DESCRIPTION

This is a 1-Transistor Detector radio without using a Germanium Diode. The only difference you will find is that Germanium Diode Detector radio can not be used for amplification of radio wave, but this 1-Transistor Detector radio can function in both detection and amplification. The radio wave entering the antenna is detected by passing through the Transistor Base and Emitter and becomes audio current. This audio current is amplified when passing through the Collector, thus enabling better listening than obtained from a Germanium Diode Detector radio.

HOW TO USE 3.0 V: If you find the signal wave so weak that you shall not be able to obtain louder voice and sound, you should add one more dry battery 1.5 V to have a good reception. As shown in the Parts Location Diagram on page 5, the position requiring to install another battery is indicated with dotted line, in which case be sure to check the position on the negative (−) and the positive (+) ends. Moreover, you should change in connecting the lead wire as indicated with dotted line. Note that this shall also apply to the cases of the following projects.

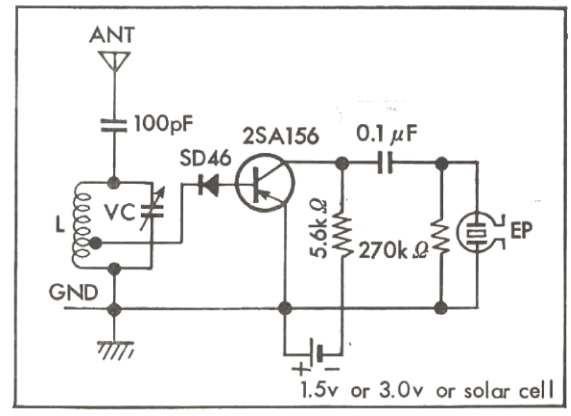
PROJECT #4 for Assembling Germanium Diode 1-Transistor Radio



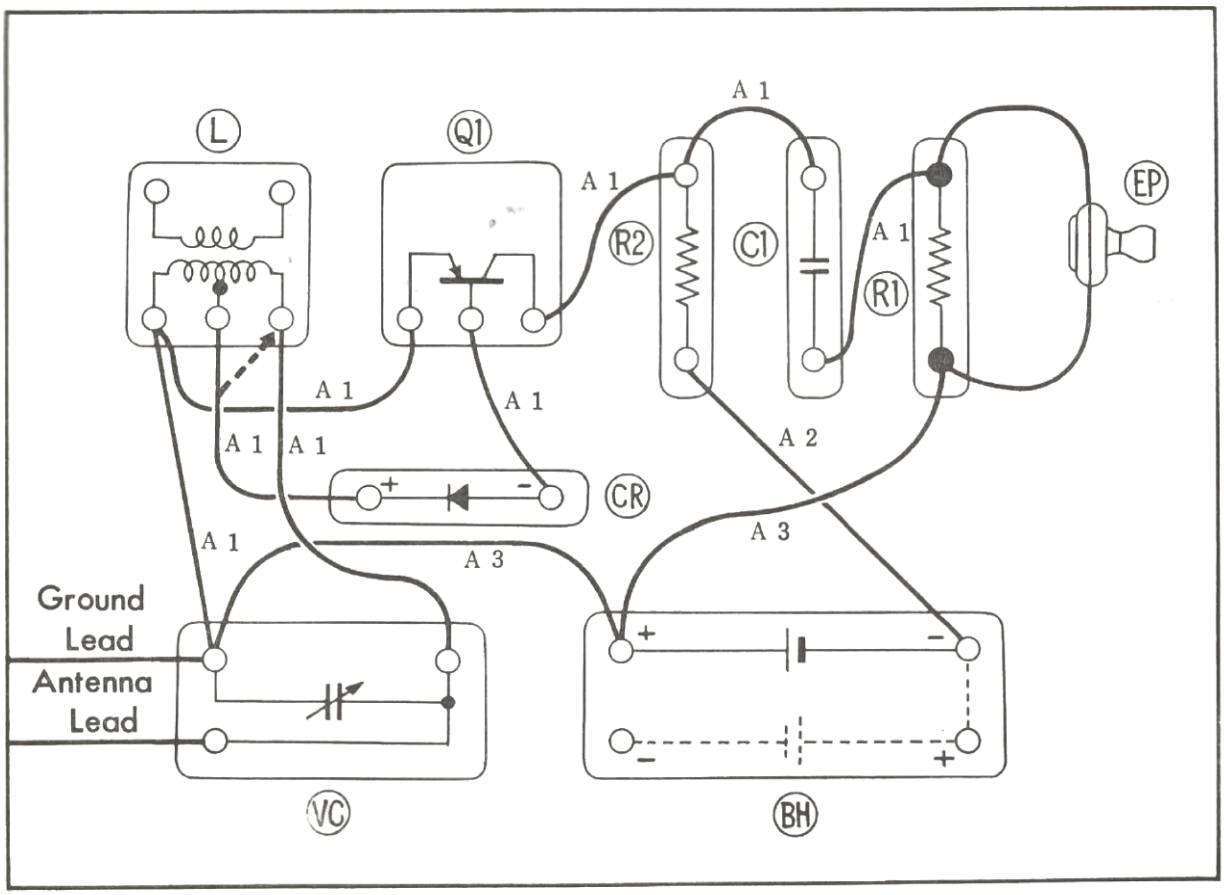
1. PREPARATION

Prepare the following 16 different parts included in this KIT:

Circuit Mounting Board	1 pc.
Tuning Coil #L	1 〃
Antenna Lead	1 〃
Variable Tuning Capacitor #VC	1 〃
Germanium Diode #CR	1 〃
Transistor #Q1	1 〃
Resistor #R1	1 〃
Resistor #R2	1 〃
Capacitor #C1	1 〃
Crystal Earphone #EP	1 〃
Battery Holder #BH	1 〃
Dry Battery 1.5V	1 〃
Ground Lead	1 〃
Connecting Lead #A1 (Blue)	8 pcs.
Connecting Lead #A2 (Brown)	1 pc.
Connecting Lead #A3 (Green)	2 pcs.



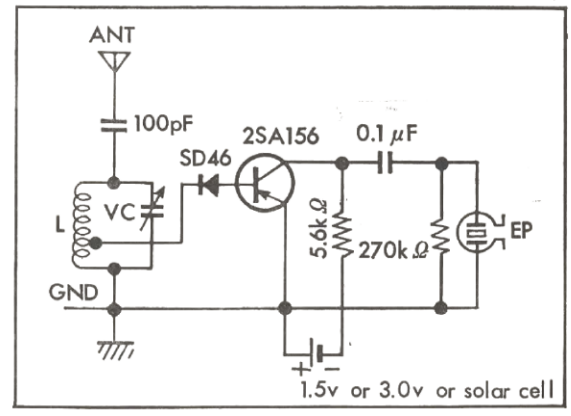
PROJECT #4 for Assembling Germanium Diode 1-Transistor Radio



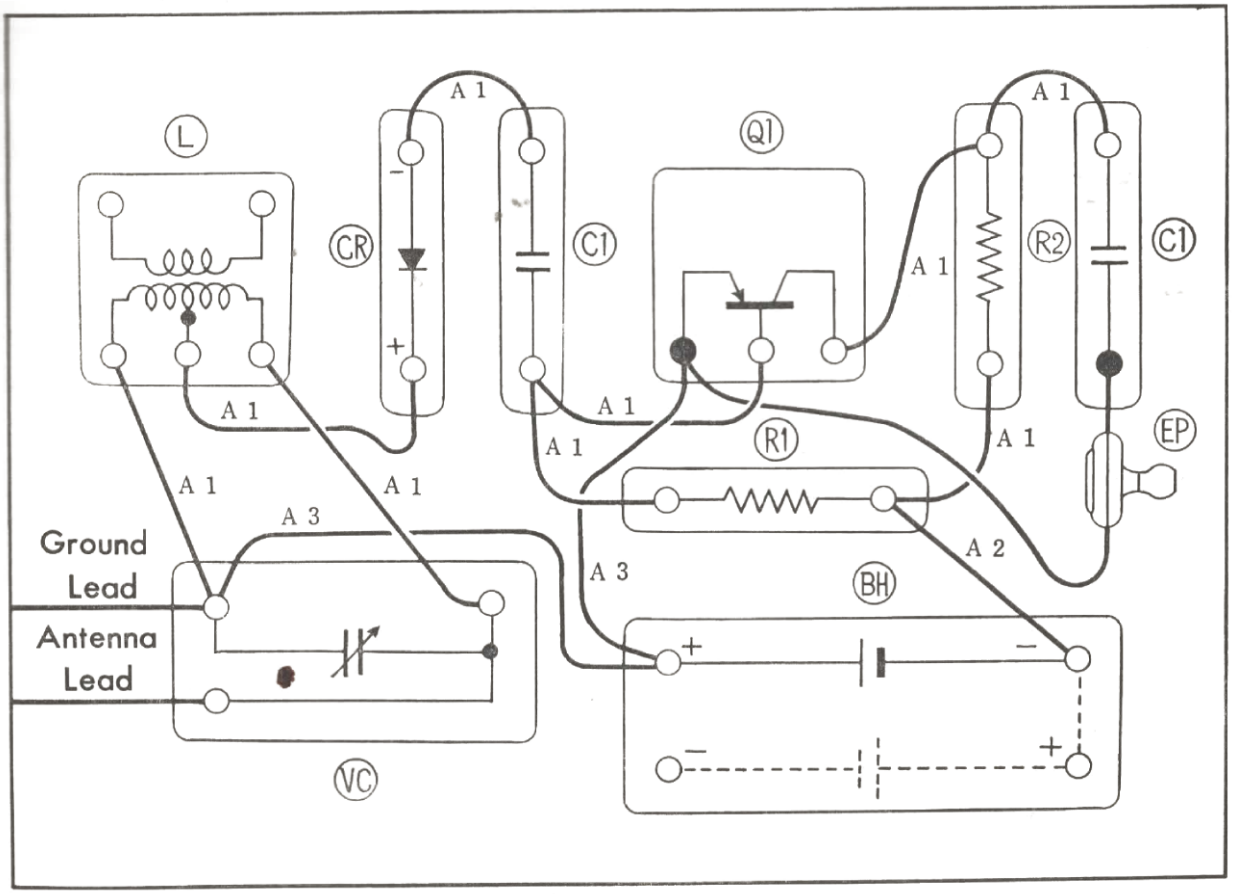
1. PREPARATION

Prepare the following 16 different parts included in this KIT:

Circuit Mounting Board	1 pc.
Tuning Coil #L	1 〃
Antenna Lead	1 〃
Variable Tuning Capacitor #VC	1 〃
Germanium Diode #CR	1 〃
Transistor #Q1	1 〃
Resistor #R1	1 〃
Resistor #R2	1 〃
Capacitor #C1	1 〃
Crystal Earphone #EP	1 〃
Battery Holder #BH	1 〃
Dry Battery 1.5V	1 〃
Ground Lead	1 〃
Connecting Lead #A1 (Blue)	8 pcs.
Connecting Lead #A2 (Brown)	1 pc.
Connecting Lead #A3 (Green)	2 pcs.



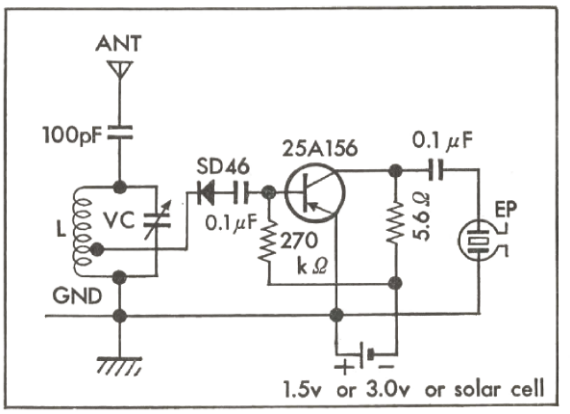
PROJECT #5 for Assembling Germanium Diode 1-Transistor Radio



1. PREPARATION

Prepare the following 16 different parts included in this KIT:

Circuit Mounting Board	1 pc.
Variable Tuning Capacitor #VC	1 〃
Tuning Coil #L	1 〃
Germanium Diode #CR	1 〃
Capacitor #C1	2 pcs.
Transistor #Q1	1 pc.
Resistor #R1	1 〃
Resistor #R2	1 〃
Crystal Earphone #EP	1 〃
Battery Holder #BH	1 〃
Dry Battery 1.5V	1 〃
Antenna Lead	1 〃
Ground Lead	1 〃
Connecting Lead #A1 (Blue)	9 pcs.
Connecting Lead #A2 (Brown)	1 pc.
Connecting Lead #A3 (Green)	2 pcs.



2. HOW TO ASSEMBLE

(1) Mount each parts on the Circuit Mounting Board from the left hand as shown on the Parts Location Diagram.
(2) Be sure to mount the Germanium Diode, Transistor, and Battery Holder in the right position as shown on the Parts Location Diagram.
(3) Check carefully with the Parts Location Diagram after completely mounted.

3. HOW TO CONNECT EACH LEAD

Be sure to connect each Lead sidewards to the proper terminal root. For removing all the Leads, simply slide them upwards,

(1) Connect each Lead from the left parts as shown on the Parts Location Diagram.
(2) Connect each Lead to the proper terminal root tightly.
(3) Then, connect Earphone, Antenna & Ground Leads to the right position.
(4) Check carefully whether all connections are correctly made.

4. RECEPTION

When you find the wiring work done properly, you may proceed to install Battery to the proper position of the Battery Holder to make this set operate. Be sure to check the position on the positive (+) and the negative (−) ends.

The dial towards "0" indicates lower frequency while towards "10" indicates higher frequency. Tune slowly the dial knob of Variable Tuning Capacitor to have a good reception. If this receiver does not work, check to see that good antenna and ground connections are used.

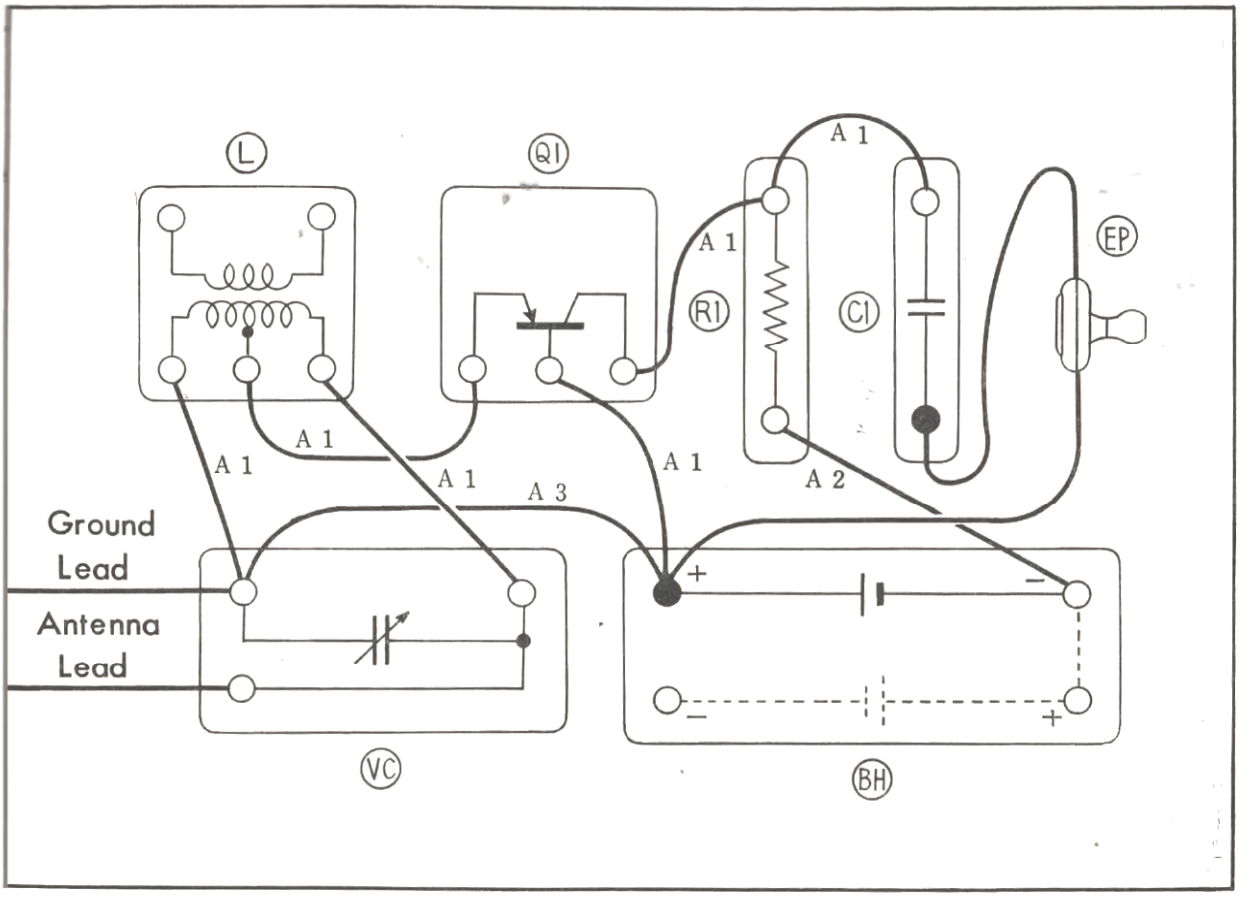
5. CIRCUIT DESCRIPTION

This is a same type of Germanium Diode Detection and Transistor Amplification radio as shown in Project No. 4 except that the amplifier circuit is separated from the detector circuit.

The radio wave picked up by the Antenna will be tuned in the tuning circuit and become audio current by the detection of the Germanium Diode. The current will then pass into the Transistor to be amplified so as to enable hearing by earphone. Such amplification of audio current is called "Low Frequency Amplifier" or "Audio Amplifier", the sound of which can be amplified as much as 10,000 times if more transistors are added. In the case of larger power types of transistors being used, a speaker can be activated as one transistor can usually amplify its sound from 50 to 100 times.

Crystal Earphone: Earphone using Rochelle-Salt or other crystal elements to convert audio frequency into sound wave.

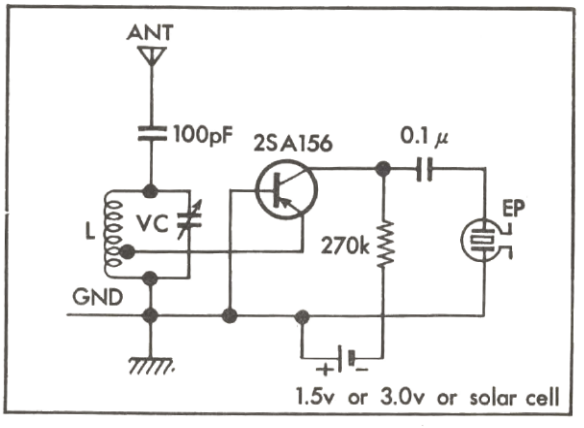
PROJECT #6 for Assembling Grounded Base Detector 1-Transistor Radio



1. PREPARATION

Prepare the following 14 different parts only out of the entire parts included in this KIT.

Circuit Mounting Board	1 pc.
Antenna Lead	1 〃
Tuning Coil #L	1 〃
Variable Tuning Capacitor #VC	1 〃
Transistor #Q1	1 〃
Resistor #R1	1 〃
Capacitor #C1	1 〃
Battery Holder #BH	1 〃
Dry Battery 1.5V	1 〃
Crystal Earphone #EP	1 〃
Ground Lead	1 〃
Connecting Lead #A1 (Blue)	6 pcs.
Connecting Lead #A2 (Brown)	1 pc.
Connecting Lead #A3 (Green)	1 〃



2. HOW TO ASSEMBLE

Apply previous instructions.

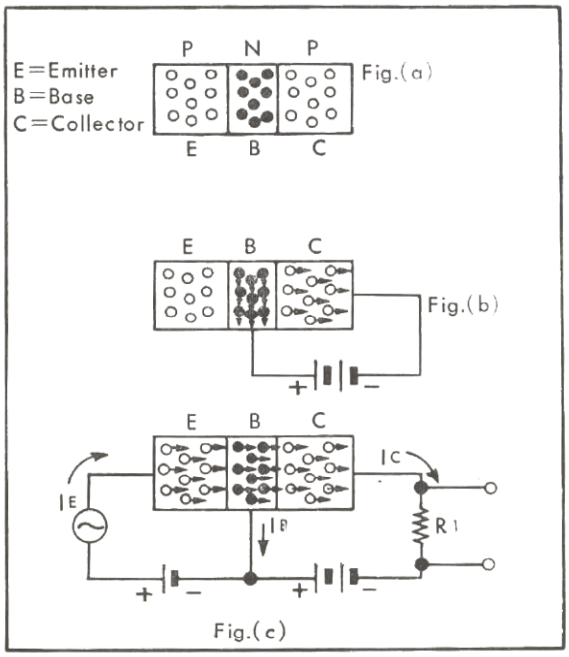
3. HOW TO CONNECT EACH LEAD

Apply previous instructions.

4. RECEPTION

Apply previous instructions.

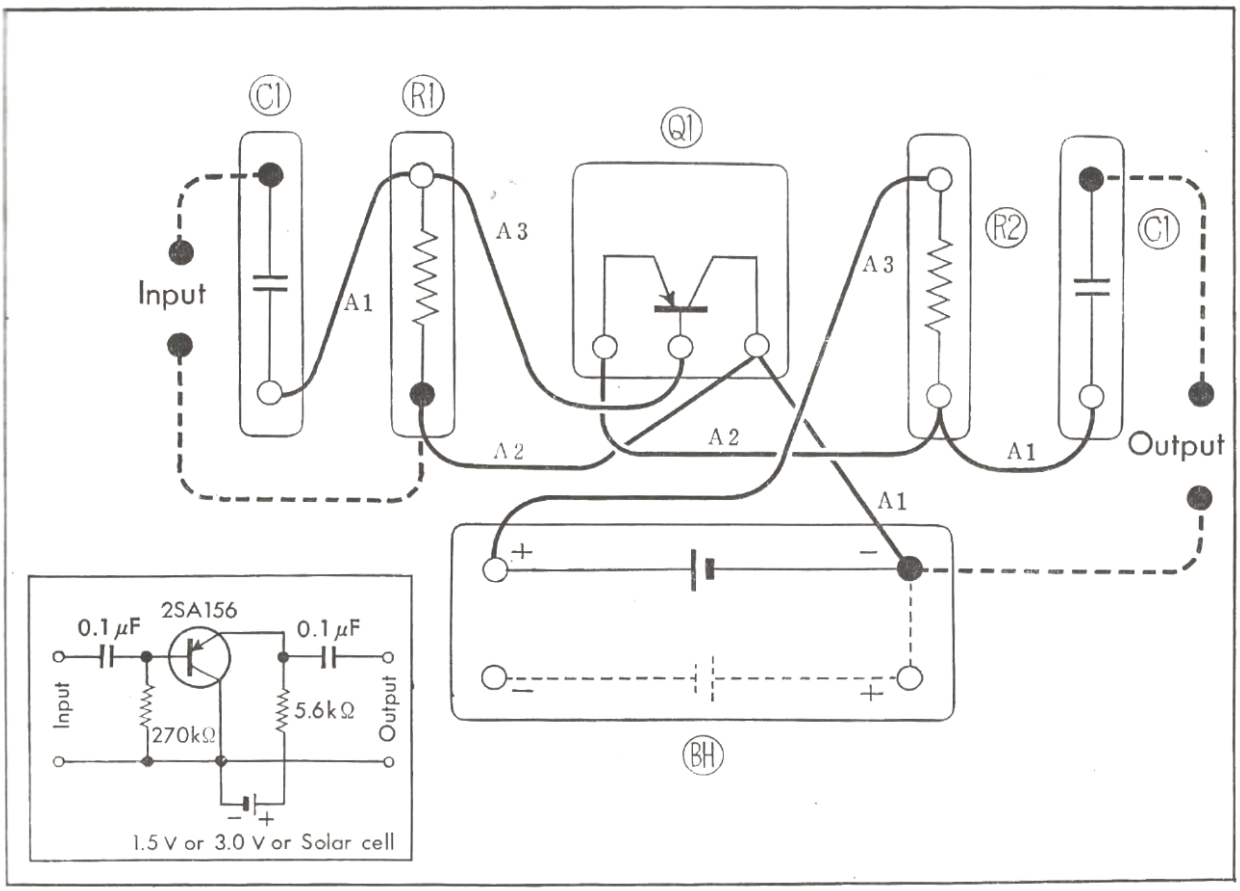
5. CIRCUIT DESCRIPTION



This is a Grounded Base Detector 1-Transistor radio. The Base is connected to the ground. The radio wave flowing in between the "Base and Emitter" will be detected and amplified.

To explain the works simply, a typical transistor is made of Germanium as the main material and as shown in Figure (a), its construction is called the "PNP" type. As shown in Figure (b), when battery current is connected to the "Base and Collector", the current will be blocked between these two sections because the battery current voltage is reversely set. To have the current flow, another battery feeding in between the "Base and Emitter" must be placed as shown in Figure (c). In this case, electrons will flow from the "Emitter" to the "Base" and further to the "Collector", resulting in a current flow as shown in Figure (c). Then the current will flow into the Load Resistor #R1 and its output will emit from both ends of the Resistor as voltage. In such a way, when the radio wave is fed between the "Emitter and Base", it will be detected and converted into audio current. When the current is applied to the "Collector", it will cause a power output from the Resistor #R1. In this Grounded Base type, when comparing the current flowing into the "Emitter" and the current flowing out of the "Collector", the latter will be lowered by about 2%, so it would be advisable to provide a high resistance of 270K ohms as the Load of the "Collector" in order to raise high voltage on both ends of the Resistor.

PROJECT #7 for Assembling Grounded Collector Amplifier



1. PREPARATION

Prepare the following 10 different parts only out of the entire parts included in this KIT :

Circuit Mounting Board	1 pc.
Transistor #Q1	1 〃
Capacitor #C1	2 pcs.
Resistor #R1	1 pc.
Resistor #R2	1 〃
Battery Holder #BH	1 〃
Dry Battery 1.5 V	1 〃
Connecting Lead #A1 (Blue)	3 pcs.
Connecting Lead #A2 (Brown)	2 〃
Connecting Lead #A3 (Green)	2 〃

2. HOW TO ASSEMBLE

Apply previous instructions.

3. HOW TO CONNECT EACH LEAD

Apply previous instructions.

4. OPERATION

When the output of Germanium Diode radio or of Record Player's Pick-up is given to the input of this amplifier, magnified output can be obtained and can be also heard by Earphone.

5. CIRCUIT DESCRIPTION

This is a circuit showing Grounded Collector Amplifier. As shown in the Parts Location Diagram, the Collector is connected to the ground. The audio input will pass through the Capacitor #C1 and flow into the Base and Collector, and the output will be taken out of the "Emitter".

A high input impedance and low output impedance is the feature of this circuit and it is used as a preamplifier for the purpose of impedance matching such as extended microphone lead and pick-up. This circuit is not generally used as an amplifier to increase inputs because of being less than 100% in amplification, but this circuit is technically called Grounded-Collector Amplifier. (Refer to Grounded-Collector circuit on page 83/84 of "The Rdio Amateur's Handbook, 1962 Edition, by The Headquarters Staff of The American Radio Relay League, West Hartford, Conn., U.S.A.")

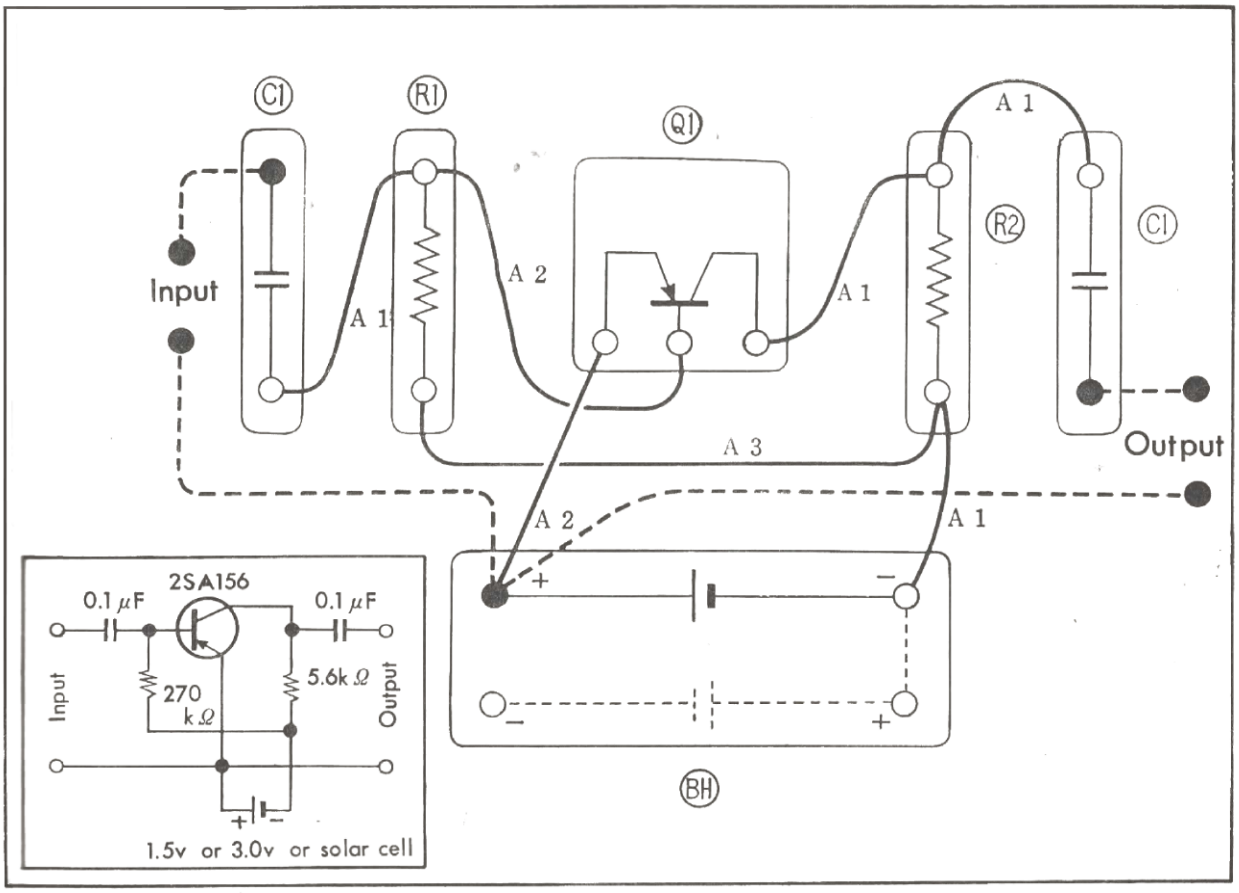
Transistor: An electronic device for rectification and/or amplification consisting of a semiconducting material to which contact is made by three or more electrodes, which are usually metal points or by soldered junctions. In essence, a transistor consists of a rectifying junction between the Base and Collector. Characteristic of such a junction is a space-charge layer. By injecting from an emitter, carriers of the opposite sign, the current carried by the junction can be altered and controlled. Compared with a vacuum tube, a transistor requires no heater current, is small and light, can be made mechanically rigid and longlasting and operates at low voltages with relatively high currents. Because of its very small size, the transistor can be used whatever compactness is desired as in hearing aids, etc.

Low Frequency: Frequencies ranging from about 15 to 15,000 cycles per second are called low or audio frequencies which are employed to create sound waves.

Detector: A device as in germanium diode for separating a signal wave from its carrier wave in detection or rectification.

Impedance Matching: The load resistance for optimum operation which is provided to attain desired value is called impedance matching.

PROJECT #8 for Assembling Grounded Emitter Amplifier



1. PREPARATION

Prepare the following 10 different parts only out of the entire parts included in this KIT:

Circuit Mounting Board	1 pc.
Transistor #Q1	1 〃
Capacitor #C1	2 pcs.
Resistor #R1	1 pc.
Resistor #R2	1 〃
Battery Holder #BH	1 〃
Dry Battery 1.5V	1 〃
Connecting Lead #A1 (Blue)	4 pcs.
Connecting Lead #A2 (Brown)	2 〃
Connecting Lead #A3 (Green)	1 pc.

2. HOW TO ASSEMBLE

Apply previous instructions.

3. HOW TO CONNECT EACH LEAD

Apply previous instructions.

4. OPERATION

When the output of Germanium Diode radio or of Record Player's Pick-up is given to the input of this amplifier, magnified output can be obtained.

5. CIRCUIT DESCRIPTION

This is a circuit showing Grounded Emitter Amplifier. In using Transistor, there are three basic elements in function to be considered, that is to say, Grounded Emitter, Grounded Collector and Grounded Base to meet respective purposes and uses. The Grounded Emitter is most widely used.

To explain how it works, first the Emitter is connected to the ground and the audio input current is fed between the "Emitter and Base" and this output will be taken from the Collector after it is amplified. This circuit is called "Resistance Coupled Amplifier". The signal coming into the input terminals will pass through the Coupling Capacitor #C1 to reach the Base. The Capacitor #C1 works for shutting off the flow of direct current and prevents direct current from outside and also the Base current from flowing out. A little flow of electric current passing through the Resistor #R1 must be fed to the Base to fuction the Transistor. And naturally this Resistor will employ a function of regulating the current from the dry battery. This current is called "Base Bias Current". The signal flown into the Base through the Capacitor #C1 (showing in the input side) will be amplified and will appear in the Resistor #R2, and then will be out to the next stage after passing through the Capacitor #C1 (showing in the output side).

Capacitor: A device consisting essentially of two conducting surfaces separated by a dielectric material such as air, paper, mica, ceramic, glass or Mylar. A capacitor stores electric energy, blocks the flow of direct current, and permits the flow of alternating current to a degree dependent on its capacitance and the frequency.

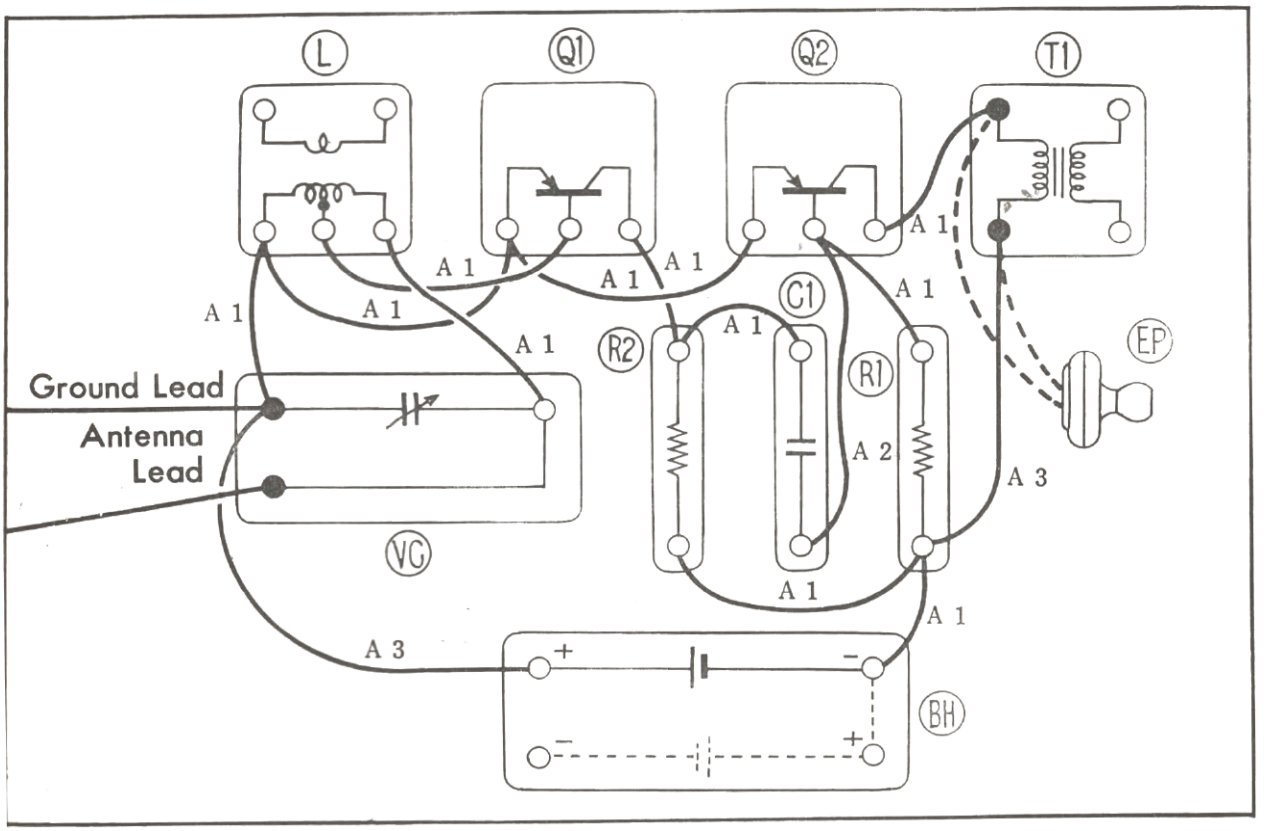
Radio Frequency: Frequencies above 15,000 cycles are called radio frequencies which are useful for radio transmission.

Tuner: In a broad sence, a device for tuning (See tuning).

Jamming: Intentional interference with radio signal.

Coupling Capacitor: A capacitor incorporated in an electronic circuit to separate a-c and d-c components, and to isolate various parts of the d-c circuit while maintaining effective a-c connections.

PROJECT #9 for Assembling Resistance Coupled 2-Transistor Radio

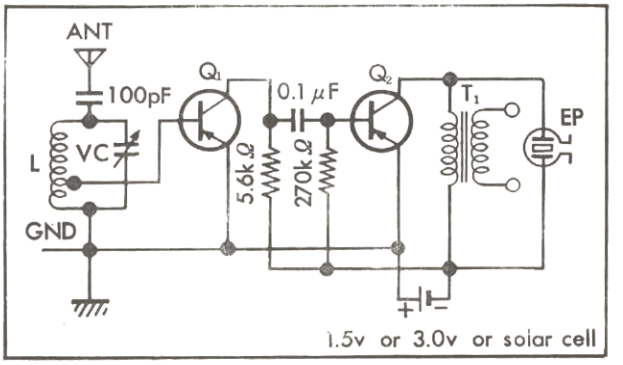


1. PREPARATION, ASSEMBLING AND WIRING

You have learnt various circuits using 1 transistor within those 8 Projects. From the Project No. 9, you will learn more circuits using 2 transistors, therein Transistor Q2 and Transformer T1 are added.

You must be by now well acquainted with the methods of preparing each parts, mounting them on the Circuit Mounting Board and connecting each lead to the proper terminal root, since the particulars have been given in the Projects from No. 1 to No. 8. From now on, you are going to select necessary parts from "Complete Parts List for Projects from No. 1 to No. 20" and "Parts Location Diagrams". Be sure to re-check your work when completed because the circuit will be more and more complicated as it advances.

You will also learn the technical symbols of every parts shown in the Schematic Diagrams. Please keep up your work by comparing the Parts Location Diagram with the Schematic Diagram.



If you are able to assemble and wire the parts by following the Schematic Diagram alone, that will be the sign you have made a remarkable progress!

2. GENERAL DESCRIPTION

This radio is virtually same to the one built under the Project #3 but with another transistor that will amplify or increase the volume of the output signal from the first transistor. The station which was barely audible with the receiver built under the Project #3 would be quite strong enough with this one. Furthermore, since Transformer #T1 is connected to the Collector of Transistor #Q2, the voltage does not drop as in case the Resistor #R1 was used; because this Transformer is a suitable component for picking out audio current, larger volume is obtained with a given number of transistors.

In order to get good results out of this receiver, a sufficiently long antenna and a good ground are necessary. You may as well experiment to find out what differences will make on sensitivity and selectivity of the receiver by using different sizes and types of antenna and ground systems.

3. CIRCUIT DESCRIPTION

Broadcast is picked up by antenna and high frequency currents flow through the antenna lead. Since many different high frequency currents exist together in the antenna lead, it is necessary to pick out the one which you wish to receive, and this is done by the combined functions of the Variable Tuning Capacitor #VC and the Tuning Coil #L. The wanted signal is picked out on both ends of the Tuning Coil #L. When connecting the Tuning Coil #L to the Base of the Transistor #Q1, the high frequency current of the selected station is detected in the same manner as it was applied to the Germanium Diode, and furthermore is amplified by virtue of the function of the transistor, resulting a relatively strong signal across the 5.6 kilo ohm resistor connected to the Collector.

The reason that a transistor functions as detector and amplifier at the same time is because, as explained in the Project #6, the Emitter, Base and Collector are brought together in intimate contact to form a sandwichlike junction, and on account of the incoming high frequency current, the Emitter forming this junction surface radiates electrons which are picked up by the Collector. The third element, namely, the Base regulates the density of electrons of the Base layer, thus varying the current flow in the transistor.

In this radio, the role of the detector is performed by the Emitter junction which is essentially the same as Germanium Diode, and the detected current functioning as a Base Bias allows amplification by the both junctions. The output of this stage is better than that of a Germanium Diode detection which you have already experimented under the Project #3 but you probably wish to get a larger volume than that. Therefore, the audio signal is picked out across the 5.6 kilo ohm Resistor #R2 and is

fed to the Base of the Transistor #Q2 of the next stage through the 0.1 micro farad Capacitor #C1 to be amplified. This Capacitor does not allow the flow of Collector current of the Transistor #Q1, which is direct current but allows the flow of audio current which is an alternating current—exactly serving the purpose. Such a Capacitor is called "Coupling Capacitor" or "Blocking Capacitor". The base of the Transistor #Q2 is supplied with a bias voltage through the 270 kilo ohm Resistor #R1, so that the audio current swings to both sides of the base bias, resulting a larger alternation of Collector current.

The proportion of the base current variation to the Collector current variation is called "Beta (β)" of this transistor, so larger the ratio is, the larger will be the amplification of the transistor.

Now you will study the function of Transfomer #T1. Transfomer is a device in which 2 sets of coil are wound over a steel core side by side so that they are electrically coupled. When only 1 set of coil exists, this device is called "Choke" which makes the alternating current flow difficult. However, choke has hardly any resistance to direct current. It is understood that choke has exactly an opposite characteristic to that of capacitor. Therefore, most of the audio current flowing from the Collector of the Transistor #Q2, after the input being amplified "Beta" times, are impeded by the choke.

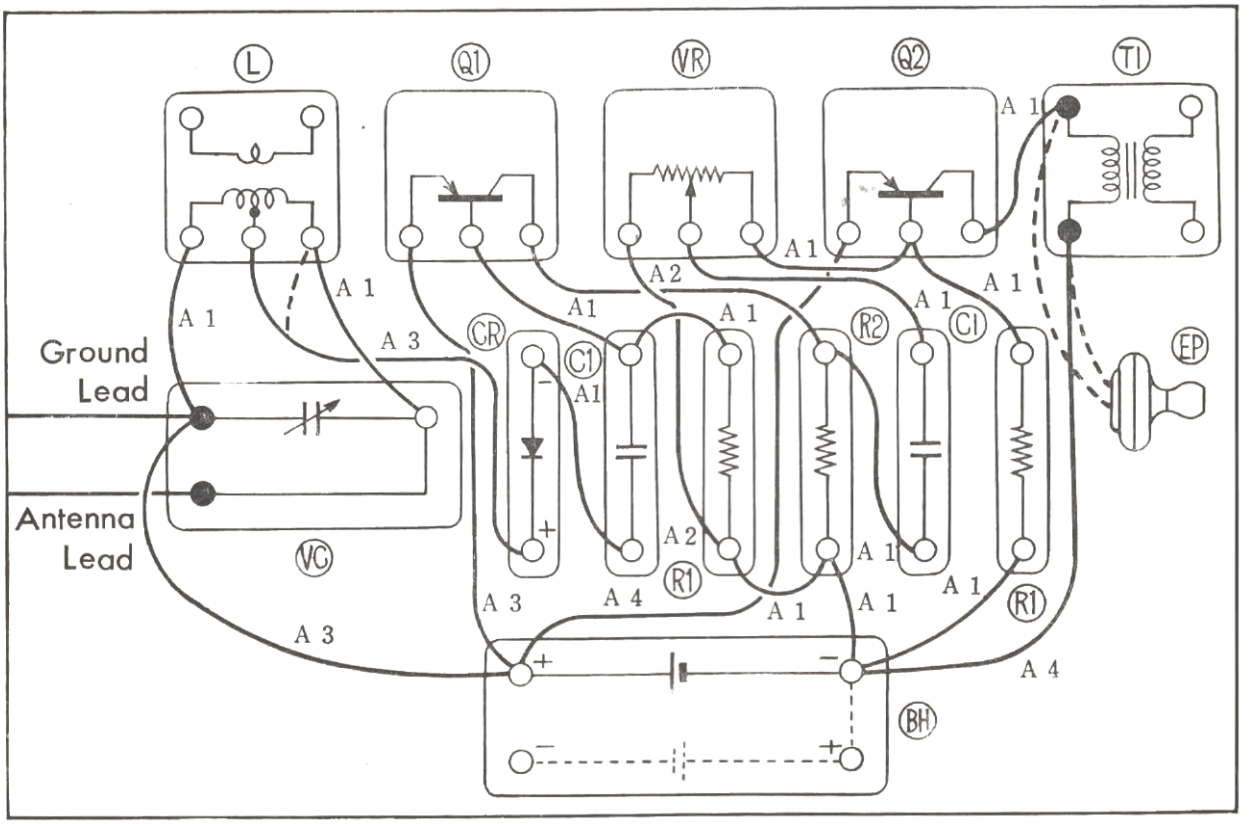
On the other hand, the voltage of the battery is free from any resistance by the choke as explained before, so 1.5 volts which is almost equal to the original voltage of the battery is applied to the Collector to give far better results with loud signal on the earphone than in case of connecting a resistor (for instance, 270 kilo ohm or 5.6 kilo ohm) to the Collector, because a higher voltage on the Collector also increases the amplification ("Beta') of the transistor.

The difference between choke and transformer is that the former has 1 coil while the latter has 2. If alternating current is applied to one of these coils, similar alternating current with voltage proportional to the ratio of turns of these 2 coils will be induced in the 2nd coil, although there is no direct connection between these 2 coils. Therefore, transformer is an useful device for producing a low A.C. voltage from a high A.C. voltage or any given high voltage from a relatively low voltage.

Supplying a negative voltage to the Base through the Resistor #R1 has been common practice to all circuits except for detection. This system has been explained as "Base bias" system, but the method applied in this Kit is called "Fixed bias" or "Series bias" method. This is the simplest method, and although the value of this resistor is governed by the type of transistor and its usage, it is usually from 10 kilo ohm to 200/300 kilo ohm.

The value of the Capacitor #C1 connected to this Resistor is decided by the lowest audio frequency (in terms of cycle) flowing through it. If a small capacitor is used, the audio signal will lack "Bass".

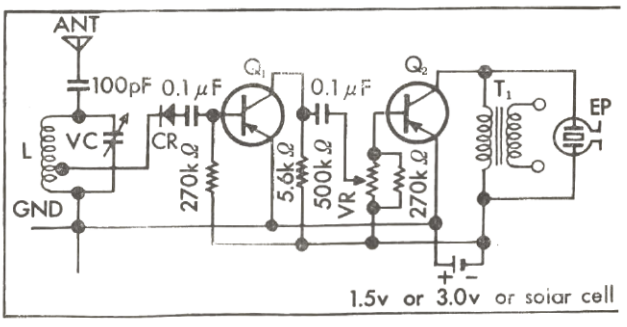
PROJECT #10 for Assembing Germanium Detected 2-Transistor Radio



1. GENERAL DESCRIPTION

This project is simply an addition of one amplifier stage equipped with a volume control to the Project #5, which deals with a radio consisting of a germanium diode and a transistor functioning independently as detector and amplifier.

Utilization of the germanium diode in this radio makes this set versatile. Usage of this set as radio is same as already explained in the Project #9. The Transistor #Q1 and Q2 are both supplied with base bias voltage and in putting the detector circuit aside, it can be used independently as audio frequency amplifier. Therefore, if a microphone is connected to the base of the Transistor #Q1, it will serve the purpose as portable amplifier or hearing aid in small output. You can well imagine from this how the public address system works.



If the output of a record player pick-up is fed across the base of the Transistor #Q1 and the ground, it will

also serve the purpose as phonograph amplifier by boosting the sound picked up from the groove of record. Since the sound on the record is emphasized in the region of "Treble" and is weakened in the region of "Bass" during the process of recording, a real hi-fi sound cannot be attained unless a "Compensation circuit" is attached to it as the regular hi-fi set has. However, from this experiment you can learn how the sound from the record is transformed into electricity through the phonograph pickup, and is amplified and reproduced again to music through earphone.

Volume control is done by variable resistor in all cases, and the proper way of wiring is to make the volume maximum when it is turned to to the right and minimum when turned to the left.

2. CIRCUIT DESCRIPTION

Countless radio broadcasts and signals fill atmosphere after being radiated from the antennas of their respective transmitters in a form in which electric lines of force and the magnetic lines of force interlock each other like a chain. The role of the antenna wire is to cut these lines of force to induce the high frequency current corresponding to these radio signals which in turn are fed to the tuning circuit, consisting of the Variable Tuning Capacitor #VC and the Tuning Coil #L, where a desired signal is picked out.

The Capacitor #C1 blocks the direct current portion of detector output but lets through the audio current which is the output of the detector and feeds it to the base of the Transistor #Q1. As the signal is fed into the Base of the Transistor #Q1, this signal will form a current alternating on both sides of the Base Bias (direct current) and the amplification of this transistor will result "Beta" times current variation at the Collector (Refer to the Project #9). Then this already amplified signal is fed to the base of the following Transistor #Q2 through 0.1μF capacitor, where the signal is amplified again, and together with the effect of the Transformer #T1, a louder signal is reproduced from the earphone.

There are two reasons for connecting VR & R1 (270 kilo ohm) in parallel. The first reason is to reduce the total value of the resistance to provide the right base bias voltage, and the other is to regulate the input signal of the Q2 by splitting the output of the Q1 by varying the resistance of the VR.

3. ADVANCED STUDY ON PROPERTIES OF TRANSISTOR— on "Alpha (α)" and "Beta (β)"

The role of a transistor is to control the flow of electrons so as to "amplify" or "detect" different signals. Therefore, the larger the capability of controlling the electrons, the better transistor it is. Symbols expressing the capabilities of transistors are α (Alpha) and β (Beta). If you check the α and the β of a given transistor from data book, you can find out offhand what efficiency that transistor has.

It was mentioned before that there are 3 basic circuits, namely, Grounded Base, Grounded Emitter and Grounded Collector. The rate of current amplification for the Grounded Base is called α and that of Grounded Emitter is called β. Figure 10-1 shows an example of the Grounded Base Circuit. When we say "Grounded", this does not mean that it has to be connected to the earth but means that the wiring common to input & output has a ground potential, in other words 0 volt.

If 1 mA (milli-ampere) audio current is fed into the Emitter of this circuit, 0.98 mA current will flow out of the Collector and 0.02 mA, out of the Base. This is apparent from the following law:

The Kirchoff's Law states that the sum of all the currents flowing toward any point or junction in an electric circuit is equal to the sum of all the currents flowing away from that point.

The ratio between the signal appeared at the Collector (0.98 mA) and the signal applied to the Emitter (1 mA) is α, and the α is shown as, $\alpha=\Delta I_C/\Delta I_E$ (Δ denotes small value in mathematics). Applying the above figures, α is equal to 0.98/1=0.98.

When this transistor is operated as Grounded Emitter as shown in Figure 10-2 and 0.02 mA signal is fed into this Base, 0.98 mA current flows out of the Collector and the current flowing through the Emitter will become I_B+I_C (I_B means Base Current and I_C means Collector Current).

The rate between the output current and the input current is called β, which is the amplification factor of this circuit. Therefore, $\beta=\Delta I_C/\Delta I_B=0.98/0.02=49$.

The relation between α and β is shown in the following equation:

$$\beta=\frac{\alpha}{1-\alpha}$$

Therefore, if α is known, β can be calculated.

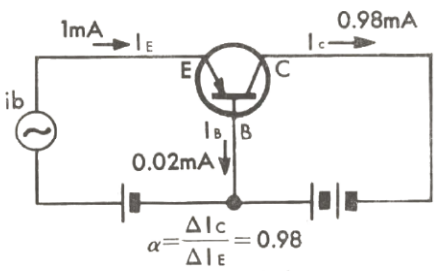


Fig. 10－1 Grounded Base Type

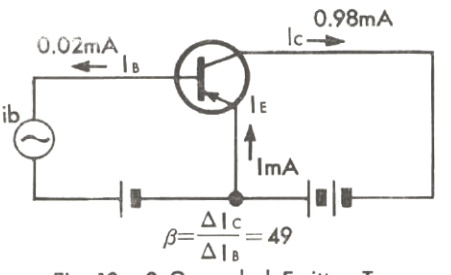
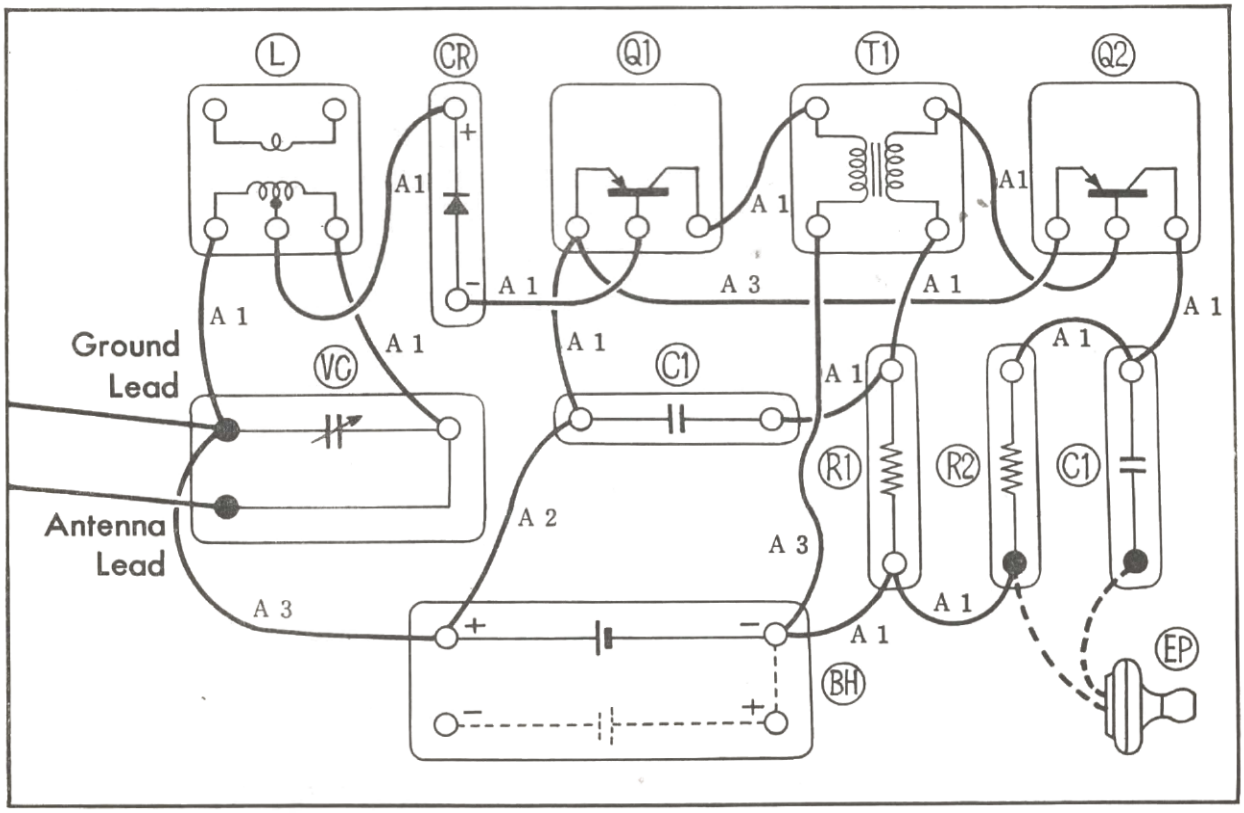


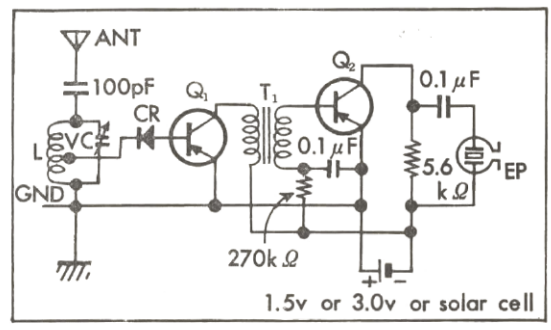
Fig. 10－2 Grounded Emitter Type

PROJECT #11 for Assembling Transformer Coupled 2-Transistor Radio



1. GENERAL DESCRIPTION

You will understand the function of this radio better than that of the Project #4 that you have already experimented, which deals with Germanium Diode 1-Transistor Radio. That is to say, the load resistor #R2 in Project #4 is replaced by the Transformer #T1 at the 1st transistor amplifier stage and the coupling to the following amplifier stage the Q2 is also made through the secondary winding of the transformer #T1 in this Project #11. The output of the Q2 is treated in the same manner as the Project #4. As a radio, this set gives you larger volume than that of the Project #4, and it would be possible to receive broadcasts from distant stations which were impossible before due to insufficient amplification.



A good antenna and ground system should be provided to expect best results is this Project as in case of the Project #9 and #10. This Project gives you an opportunity to learn about transformer coupling and the method of supplying bias voltage to the Q2 when transformer is used.

2. CIRCUIT DESCRIPTION

The previous explanations on reception of signal and on tuning circuit can be applied to this circuit. Since the output potential of the germanium diode is negative (minus), its output current can be applied directly to the Q1 as a base bias, eliminating base bias circuit using the R1 as previously done. If the potential of the CR is reversed, the base bias current will not flow and the Q1 will not function. However, if you are using NPN type transistor, you will have to reverse the potential.

The winding of the Transformer #T1 connected to the Collector of the Q1 is called "Primary" and the other connected to the Base of the Q2 is called "Secondary". The resistances of the "Primary" and the "Secondary" against alternating current are designed in order to match with the load resistance of the Q1 Collector and with the input resistance of the Q2. Transformer provides ideal matching of input and output resistance, which is especially important to transistor circuits, and enables to amplify the signal with lesser loss than using resistor and capacitor. This system is widely applied to different electronic circuits, but there are some drawback to use in a "hi-fi" system.

The Base bias of the Q2 is applied through the R1 connected to the secondary winding of the T1, and the C1 (0.1μF) is connected to the junction. This C1 is called "By-pass capacitor", inserted in order to provide a "short-cut" to ease the flow of the signal current.

Referring to the following Figure 11-1, the signal current is impeded by the 270 kilo ohm resistor and only a little current flows through it. In other words, the path for the signal becomes narrow and makes it difficult to pass through. So, if a wide and "Easy-to-pass" path is provided, signal will naturally flow through the wider path. Thus the signal current flowing in the transformer will increase and stronger signal will be applied to the Base of the Q2.

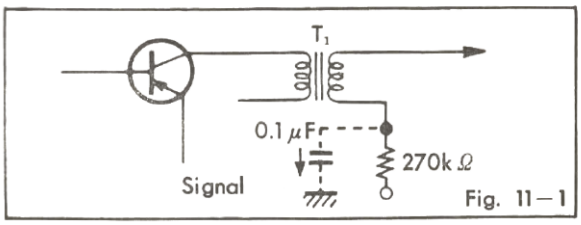
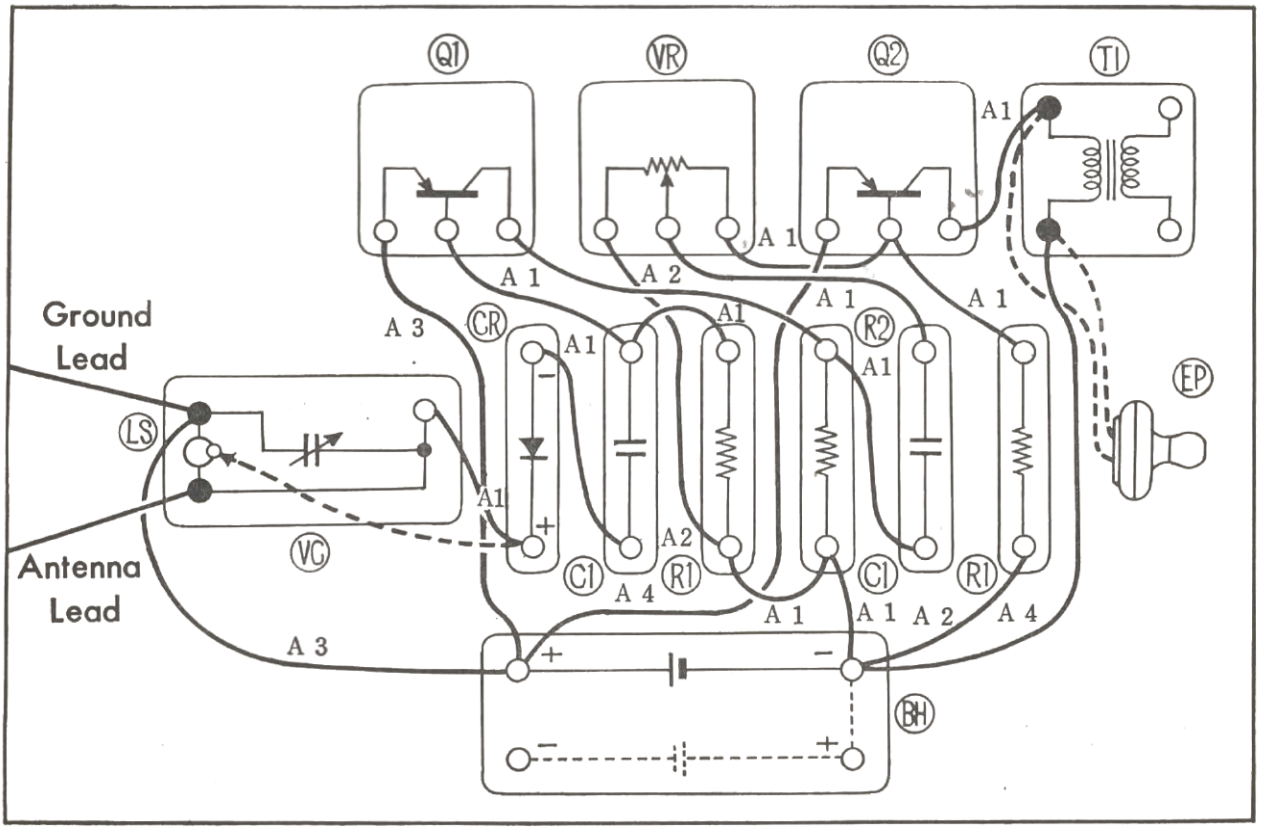


Fig. 11-1

Germanium Diode: A Diode consisting of a semiconducting material such as a germanium or silicon as one electrode and a fine wire "whisker" resting on the semiconductor as the other electrode. Because of its low capacitance, the device finds considerable application as a rectifier or detector of microwave frequencies.



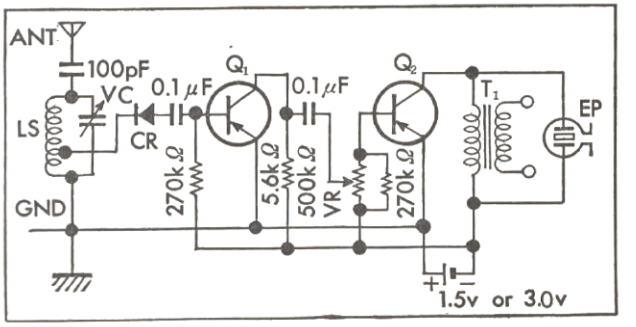
1. INTRODUCTION

Short wave is an abbreviation of "Short Wave Length". The frequency range of the standard broadcast band, which is called "Medium Wave", is from 535 kc to 1,605 kc. The short wave covers from 3,000 kc (3 Mc) to 30,000 kc (30 Mc), and a receiver tunable to such frequency is called a short wave receiver.

Since the velocity of radio wave is known as 3×10^{10} centimeter per second, the wave length of a given frequency can be calculated from the following equation:

$$\text{Wave length (in meters)} = \frac{300{,}000}{\text{Frequency (in kilo cycles)}}$$

For instance, if the frequency of a given medium wave station is 590 kc, the wave length will be 508 meters according to the above equation. Likewise, if the frequency of a short wave station is 3.925 Mc (3,925 kc), the wave length will be 76 meters, which you will see very short. Short Wave is used for Overseas



Telephone, International Broadcast, Maritime Radio, Amateur Radio (ham) and many other means of communication because it has such a characteristic that the short wave can reach far distance, not as in case of the medium wave.

The ordinary medium wave, which is classified as direct wave and ground reflected wave, is called space wave. The direct wave radiates straight from the transmitting antenna to the receiving antenna or further to the tuning circuit of a receiver and the ground reflected wave is radiated by the reflection from the earth. On the other hand, the short wave is composed of "sky wave" which is reflected at the ionosphere, 80 to 400 kilo meters above the earth, and is reflected back and forth many times between the surface of the earth and the ionosphere, enabling a signal to reach every part of the world.

To explain further on the ionosphere, it is located above the stratosphere and is divided into D layer, E layer, F layer and G layer according to the height above the ground. The density of air is extremely low in this region where molecules of different gasses are broken up to electrons and ions on account of the sun-rays and corpuscles radiating from the sun. The ionosphere is subjected by the activities of the sun and its relation with the earth, in other words, varies in accordance with the time of the day or the seasons of the year, so you will realize that constant receiving conditions cannot be expected for the short wave reception.

2. CIRCUIT DESCRIPTION AND OPERATION

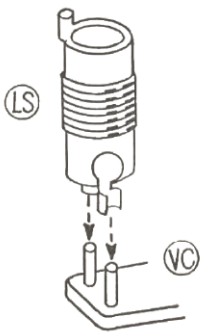


Fig. 12–1

This circuit is identical with the circuit of the Project #10, except that the tuning coil for the medium wave is replaced by a short wave tuning coil. In order to receive Short Wave broadcasts, you will have to connect the Short Wave Coil to the Variable Tuning Capacitor's terminals as shown in Figure 12-1. In this case, you will have to use a large antenna and a good ground system as in case of the Medium Wave. This is only because most of radio waves in the Short Wave broadcast are very weak and come from very far distance.

Antenna becomes very sensitive when it is cut to the right length corresponding to the wave length of a station that you wish to receive. You can easily calculate the necessary length of your antenna for a given station frequency from the above equation that enables you to convert the frequency to a desired wave length. If you want to tune in the 7 Mc amateur band, the wave length will be 300,000/7,000 (kc)= about 43 meters, so the ideal length of your antenna will be about 40 meters or half the wave length, namely, 20 meters. Unless you manipulate the receiver skilfully, it would be difficult for you to receive a good reception for short wave in the daytime, but the condition for reception improves suddenly at night. This is because the ionized layers vary as time goes by. The E layer which is about 150 kilo meters

above the earth reduces greatly its electronic density after sunset—occasionally fades out completely—leaving the F layer exposed above the E layer, then the short wave signal is reflected and refracted directly by the F layer without being affected by the E layer, which characteristic is to weaken radio waves.

A warning signal against disturbances in the radio communication, which are caused by solar action and the other reasons, is broadcasted through the standard wave transmissions with the Morse Code Letters, and such 3 letters of "N", "U" and "D" denote the "N" for normal, the "U" for unstable and the "D" for disturbances. The letter "W" is transmitted for magnetic storm warning. You will also find the correct time of the astronomical observatory by receiving this standard wave transmission.

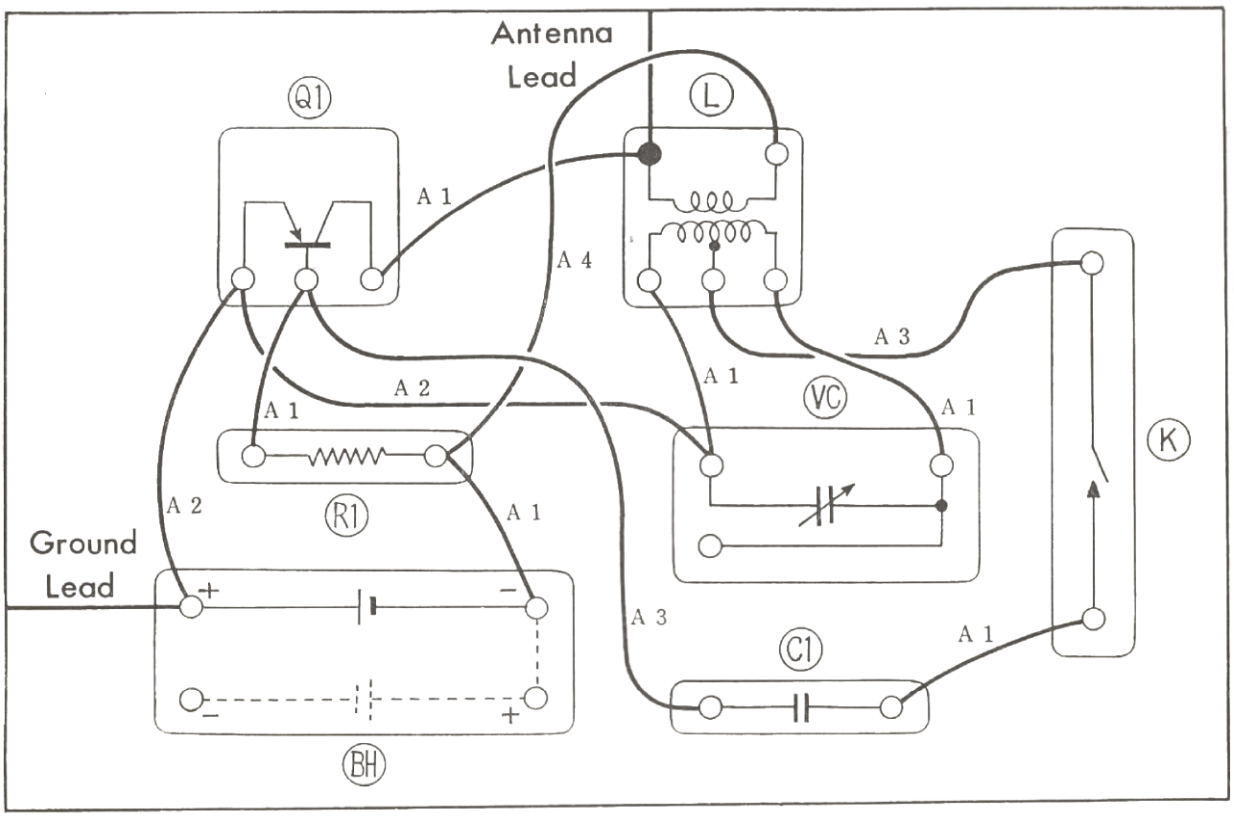
3. RADIO AMATEUR OPERATOR

Scattered over the globe, there are many radio amateur operators who are communicating with other fellows in the short wave around the 3.5, 7, 14 and 28 megacycle bands. In this radio kit, a good reception is available around the 7 Mc, but confusion like traffic street will be resulted because many closed radio frequencies are crowded in a limited narrow band. Such listeners in the shortwave bands are called "SWL", "S" standing for Short, "W" for Wave and "L" for Listener. When they inform details such as condition of sensitivity and noise, place, time, frequency and other reports to the radio operators, the operators will know the conditon of its operation in the equipments which will be very helpful in all future communication. Thereby cards known as "Verification" will be sent by them to the listeners as memorial records for the reports.

However, when we say amateur radio, we soon think of a radio operator who is licensed by the government to communicate with other fellows by shortwave radio. Ever since Marconi invented the so-called Wireless Telephone in 1895, the amateur radio station from a humble stage has been growing to become one of the most fascinating arts that are now widely scattered over the globe. Thousands of radio amateurs are constantly at work on experimenting better equipments only to contact with others. Their dreams are to earn the awards given by Headquater of Radio Association for the League-Sponsored Operating activities. For instance, in addition to other awards, the WAC (Worked All Continents) award issued by the International Amateur Radio Union (IARU) is given to those radio amateurs who have succeeded is contacting with all of the 6 Continents. On such occasion, "QSL" cards which are exchanged for their activities will be submitted to them as a proof.

In time of emergencies such as flood, etc., amateur radio operators are always at the spot to fulfil their public service. The contributions they have made in saving the lives of our citizens have been well recognized that now the government of most countries give full support to foster such radio amateurs.

PROJECT #13 for Assembling Radio Frequency Oscillator

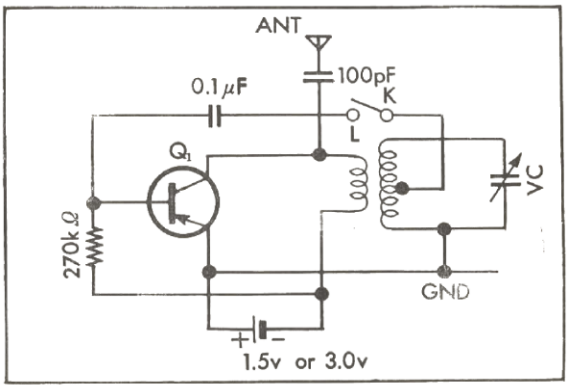


1. INTRODUCTION

You have been learning about various circuits of radios and amplifiers in the Projects from #1 to #12, so let's take up an oscillator in this Project.

Oscillator is a device for producing electric wave (alternating current) and there are 2 ways to produce it; the first way by utilizing a generator through its electromagnetic induction and the another by utilizing the characteristic of amplification of vacuum tube or transistor.

In early days of radio communication, radio waves were transmitted by means of generator, but vacuum tube took the place of the generator because of the superior efficiency after it was first introduced. Again, in accordance with a new development of transistor, production of transistorized oscillators were increased and it will not be long before such transistor can entirely replace the vacuum tube.



The oscillator is divided into 2 groups according to the frequency of the wave that produces, namely, High Frequency Oscillator (Radio Frequency Oscillator) and Low Frequency Oscillator (Audio Frequency Oscillator), and is also classified into LC Oscillator, RC Oscillator, Crystal Oscillator, Tuning Fork Oscillator and Multi-Vibrator according to the type of circuits.

2. GENERAL DESCRIPTION

By pressing the Key #K, a radio wave is produced, but no program and sound can be heard. As you know, such radio wave, being ready to carry programs or informations, is called "Carrier Wave". The regular radio broadcast is a form in which a program is put on top of this Carrier Wave, and this type of radio wave is classified as "A3 radio wave". According to the type of modulation and transmission, it is classified as A1, A2, A3, F1, F2, F3, P1 and P2.

The transmission, in which the Carrier Wave is put on and off in accordance with the Morse Code tapped on the telegraphic key, is called the A1 wave. However, if you listen the A1 wave on a regular receiver, you will not hear any program nor a sound. In order to get some informations out of such transmission, a radio receiver equipped with an oscillator (communication or ham receiver) with a frequency close to the receiving frequency is necessary. If an old-fashioned regenerative type receiver is used with excessive regeneration, it is possible to receive the A1 wave. However, it is also possible to check whether the A1 wave is radiating or not by tuning the Variable Tuning Capacitor which will cause a rushing sound or a whistling sound when it is turned to the A1 wave. By experience you will be able to tell the sound typical of carrier wave.

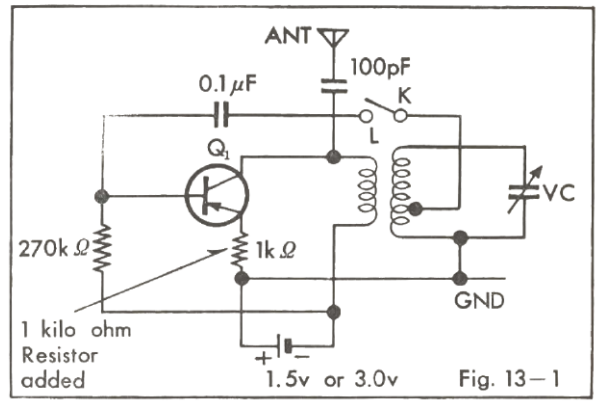


Fig. 13-1

3. OPERATION

Let's try to receive the A1 wave by a regular broadcast receiver. Turn on the switch and set the dial pointer to where there is no broadcast. Put a battery in the battery holder of this circuit (Project #13) and stretch the antena of your oscillator close to the radio receiver. Press the Key #K down and turn the Variable Tuning Capacitor until you hear a rushing sound out of the receiver. Make-and-break with the Key will enable you to hear the noise coming on and off. In order to make it a clear sound, you will have to "beat" the carrier frequency with another frequency.

As in figure 13-1, a resistor 1 kilo ohm is connected to the Emitter of a transistor. The insertion of this resistor will drop the output of the radio wave but will improve

the distortion of waveform of the output power. There will be also an effect that will comparatively decrease the harmonic wave as described in Project No. 15. The reason is that negative feedback is provided by adding a resistor 1 kilo ohm.

4. CIRCUIT DESCRIPTION

Radio Frequency Oscillator is a device for producing high frequency radio wave and is often abbreviated as "RF Oscillator". The necessary conditions for an oscillator are a good amplifier with minimum distortion for amplifying the oscillator, a tuning circuit to pick out single frequency and a circuit to feed-back a part of the output of the amplifier to its input to insure the continuous oscillation. If the amplification factor of this circuit is larger than 1, the intensity of the oscillation will be unstable and become larger, but if it is under 1, the oscillation will fade away, therefore the amplification factor has to be 1. The electrical angle (Vector) between the output and the input has to be a multiple of 0 or 360 degrees in order to sustain oscillation. If it is not so, the frequency of oscillation drifts and oscillates at the frequency of 0 degree.

In this Oscillator, "a good amplifier" corresponds to the Q1 and the "Tuning circuit" is meant by the combination of Tuning Coil and Variable Tuning Capacitor. The feeding-back of a part of the output to the input is made through the coupling between the primary and the secondary winding of the L, as well as the Capacitor #C1 connected to the tap on the secondary winding of the coil adjusted to match with the input resistance of the Transistor #Q1. The electrical angle can be adjusted by changing the potential of primary and secondary coils; the attenuation (weakening) of output can be compensated by a part of the output to be fed back; the excessive oscillation can be checked by the saturation characteristic of the collector current of the Q1—all these conditions make the oscillation stable and continuous. If the Key #K is inserted in the feed-back circuit utilizing 0.1μF capacitor and make-and-break is performed, the carrier wave will be radiated to satisfy all necessary conditions for oscillation. This is called the Tuned-Base Oscillator.

In reviewing once again the performance of oscillation, a slight variation of current at the Base brings forth a big variation of Collector current (see the Project #14 Morse Code Practising Set).

The alternating current at tne primary winding of the coil #L induces to the alternating current in the secondary coil, and the Variable Tuning Capacitor #VC connected to it is adjusted to a desired frequency. The Capacitor #C1 acts as a coupler for feeding back the resonant frequency to the base circuit of the transistor. Phasing of coil makes the feed-back positive, and when it is above a certain value, oscillation will occur. Matching of the coil to the input resistance of the Base can be made by shifting of coil tap.

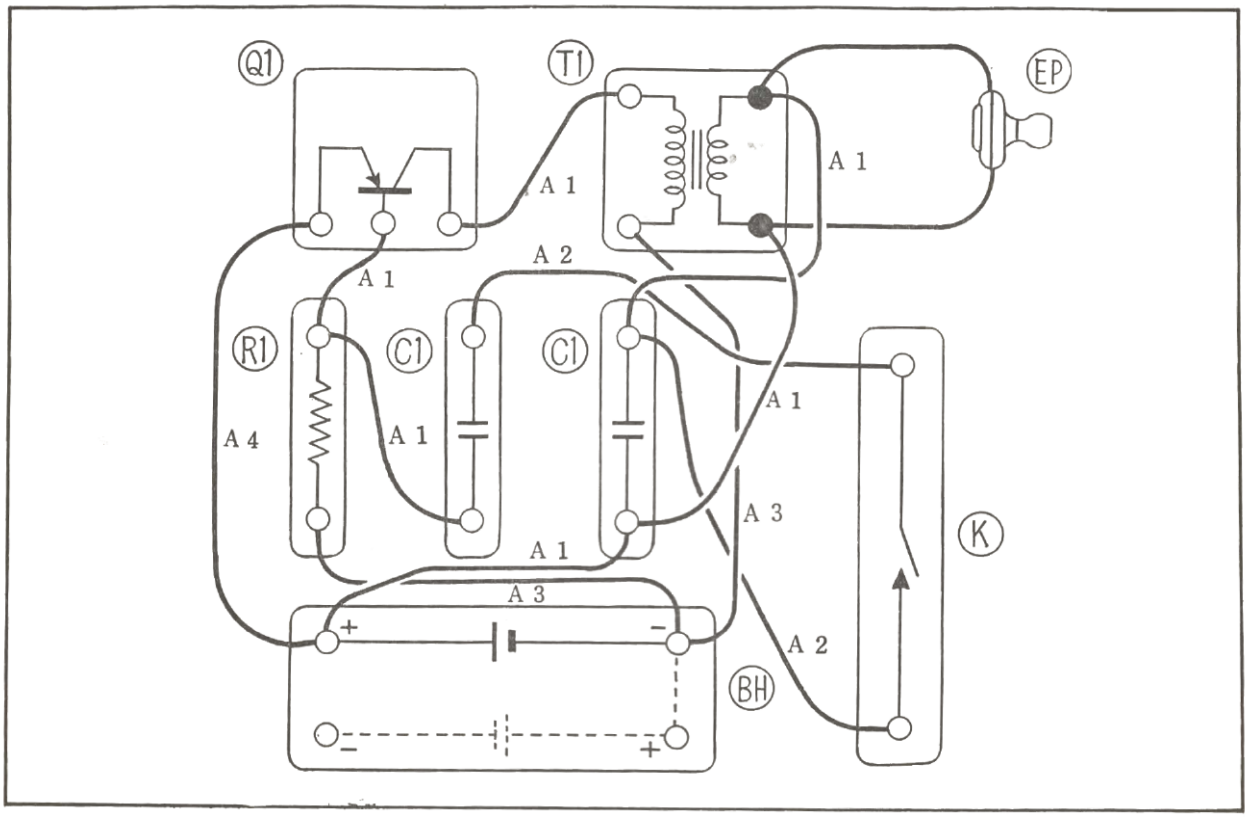
5. ON DETECTION OF THE A1 RADIO WAVE

If two electric oscillations with different frequencies, f1 and f2, are combined, a newly combined frequency f1±f2 is produced. This is called "Beat frequency". The method of detecting by producing, f1−f2, f2−f1 beat tone is called heterodyne detection. Therefore, if the difference between the receiving frequency and the local oscillator (an oscillator installed in the receiver) is adjusted to be an audio frequency, the A1 radio wave can be detected and its sound is audible. This method is applied to the regular radio receiver making the difference of the received signal and the frequency produced by local oscillator equal to the Intermediate Frequency (normally 455 kc)—this is called the Superheterodyne System.

6. HARMONICS

There is one of the frequencies called harmonics which are several tinies of the basic sound when a certain sound is produced. Not only in the sound but also in the high frequencies, there are harmonics. If the output frequency in the oscillator of A1 wave in the Project No. 13 or A3 wave in the Project No. 17 is fixed at 600 Kc, such unnecessary or excessive waves as double of 600 Kc or triple of 600 Kc will be additionally radiated. These waves resulting such phenomena, which is not required except the intended frequency, are called harmonics and must be suppressed in controlling the power to 1/1000 or less power of the basic frequency because the purpose of broadcasting cannot be achieved because of the interferences resulted from the excessive waves, just as the congestion in the street affects the traffic. In this project, the multivibrator has so many multiple harmonics that the radiated frequency will sometime be widely extended to the high frequency range—broadcasting frequency of medium waves—even though the fundamental frequency is fixed at 50 cycles. Although the harmonics are not suitable for securing the distortionless sound or waveform, it is suitable to check the operation of the signal in the circuit because the signal can be traced from low frequency (audio) to high frequency by utilizing this function with a single oscillator. This fuction of multivibrator can be also applied to signal injector to check the circuit.

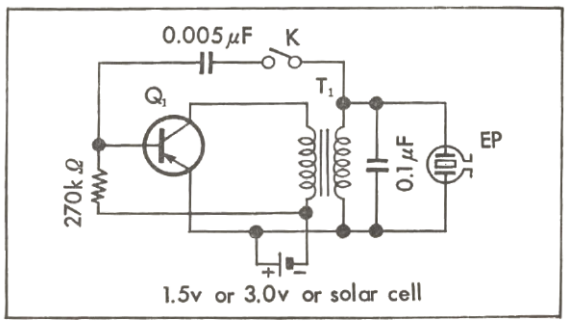
PROJECT #14 for Assembling Morse Code Practising Set
(Audio Frequency Oscillator)



1. GENERAL DESCRIPTION

This is a device for producing audible signal tone electrically, and is called audio or voice frequency oscillator. By tapping the Key #K, you will hear a long or short tone, depending upon the length of time the key is pressed down, and you can practise with this set to send the Morse Code. You can also practise receiving the correct Morse Code by a radio operator.

The long "dah" of the Morse Code should be 3 times as long as the short "dit", and the interval between "dah" and "dit" is equal to the length of "dit". Combination of "dahs" and "dits" make one letter, and the interval between letters is supposed to be the same length as "dah". For example, A ·—, B —···, C—·—·. A complete list of the codes from A to Z is given in page 49 for your practice.



2. CIRCUIT DESCRIPTION

The electrical circuit of this oscillator for producing a signal is called the Blocking type, and it is simple and works well even though the theory is very difficult to understand.

The Capacitor #C1 is charged negative through the 270 kilo ohm Resistor when the key is pressed down, and is assumed that the collector current has been blocked. Then the discharge will take place at the C1 and result the increase of voltage at the Base, and the collector current will start flowing as Base Bias is applied to the transistor. The variation of collector current is fed back to the Base by means of the Transformer #T1 and helps to build up the Base potential which will accelerate the increase of collector current so as to reach the saturating point. At this time, the "Blocking Capacitor #C1" starts gradually to be charged toward negative on account of the Base Current. As the current increases and finally saturates, the increase will stop on account of the charge of the C1, so the Collector Current decreases as the Base Voltage decreases, and the rate of decrease becomes so abrupt that the current flow will finally stop. The Base Voltage will recover again, resulting the current back to the starting condition.

The foregoing explanation is made in a very slow motion manner, but in reality, the motion is made in extremely quick cycle, maintaining an audio frequency of a constant cycle, as you hear through earphone. Such oscillation is put on and off by means of the key, and practising of the Morse Code is made possible as explained in the General Description.

Another Capacitor #C1 which is connected in parallel with the secondary winding of the Transformer #T1 is provided to adjust the tone of signal. In other words, the C1 connected in parallel with the secondary winding acts as tuning capacitor of an audio frequency tuning circuit. Output is connected in parallel to this, but you will receive same good result by connecting 1 lead of your earphone to the Collector and the another one to the negative side of the battery. If you read the foregoing example again carefully, you will understand the reason.

3. EXPERIMENT

The wave shape of oscillation of this circuit is a sine wave, but the shape is distorted as it is, so let's connect the Resistor #R2 or #R3 to the Emitter of the Q1 as shown in Figure 14–1. The greater the value of resistance is, the better becomes the shape of the wave, but if the valu is too great, the oscillation will stop. Therefore, the resistance has to be large enough but within the limit to maintain the oscillation.

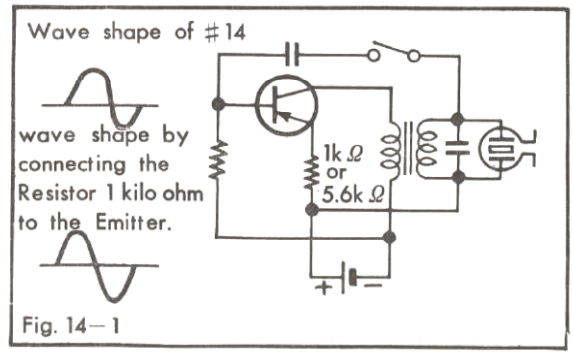
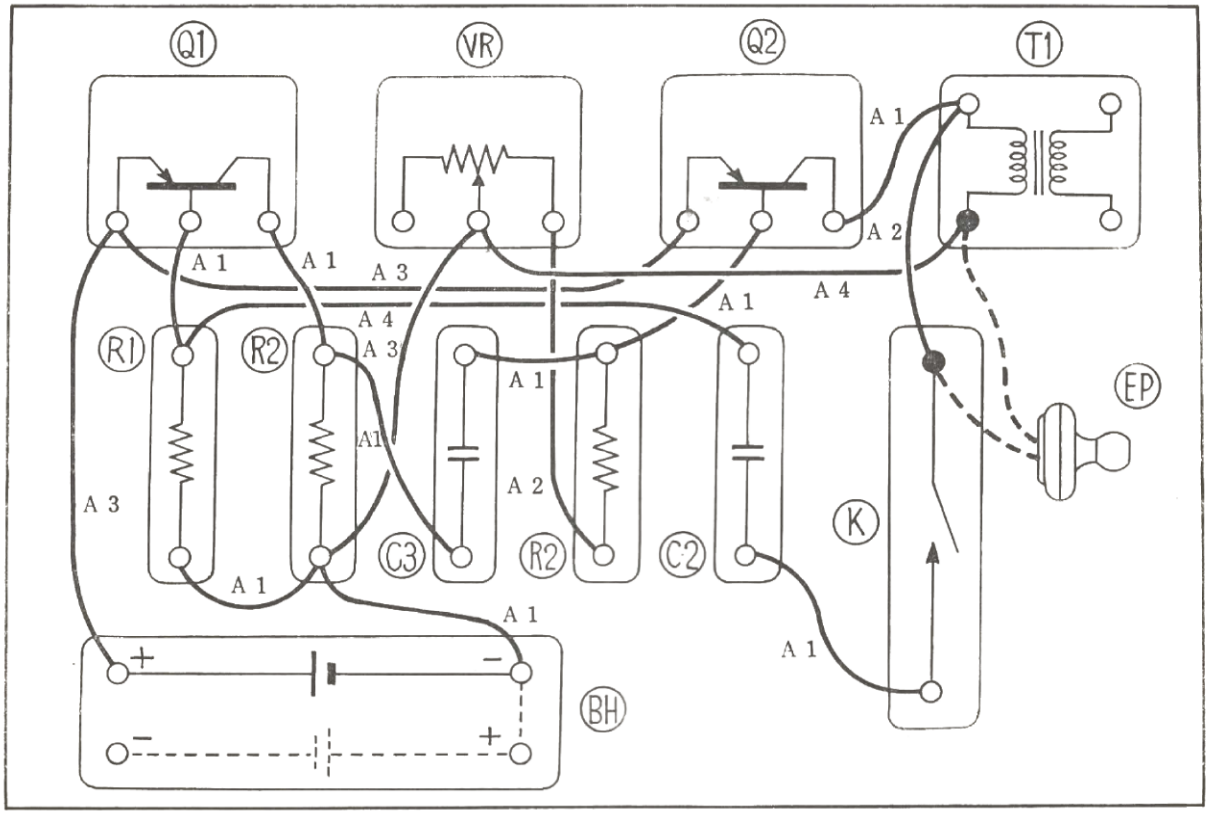


Fig. 14–1

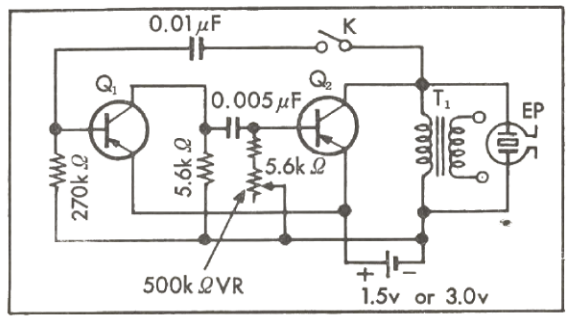
PRO JECT #15 for Assembling 2-Transistor Audio Frequency Oscillator



1. GENERAL DESCRIPTION

Among various types of oscillators using transistor, this circuit is called "Multi-vibrater", which wave shape is rectangular and contains many harmonics as the main characteristic. By utilizing that the oscillation frequency of this oscillator can easily synchronize with the signal applied from otuside, a wide application is made to the electronic field as vertical oscillator of TV and flip-flop circut for electronic computer, etc.

The input and the output of 1-transistor grounded emitter amplifier are set up at opposite phases, but when another stage of 1-transistor amplifier is connected to it, the input and the out will be in phase. If the output is connected to the input, oscillation will occur.



2. OPERATION

After completion of assembling and wiring, you will insert the battery and listen to the oscillation by pressing down

the key. The oscillatian of the Project #14 was soft and clear, but you will find the sound of this oscillator muddy due to the presence of harmonics—typical of that of the " Multivibrator ". When you adjust the VR, the value of RB2 (referring to Figure 15-1) will be changed, thus resulting a change in oscillating frequency. You should also try to assemble the fundamental circuit as shown in Figure 15-1. If assembled according to this diagram, the oscillating frequency is low as multiple of 10 cycles, but if you change the value of the C1 to that of the C2 or C3, the cycle will increase and the frequency will become higher accordingly. By means of an oscilloscope, you will be able to see the wave shape of this oscillator.

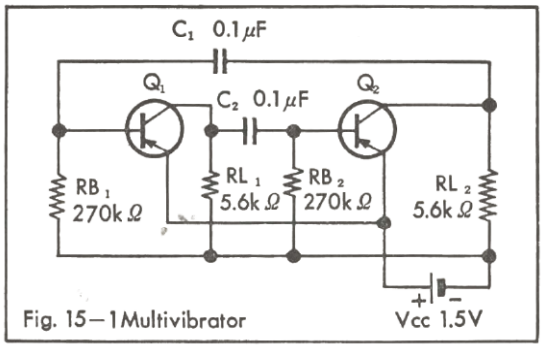


Fig. 15—1 Multivibrator

3. CIRCUIT DESCRIPTION

Let's analyze the function of this oscillator through a physical approach as shown in Figure 15-2. There is a seesaw on which a groove is cut so that the ball can roll from one end to the other without falling off from the sides or the ends. A battery and two-lamp circuits are installed under the seesaw so that when one end of the seesaw descends, the lamp at that side should light up. For example, if the ball at the left-hand side moves to the right until it stops at the end, the seesaw will move and its right-hand side will descend, so the switch at this end will be " ON " and the lamp on the same side will light up. But the lamp on the left is " OFF ". Then the ball will move from the right to the left, lighting up the lamp on the left and putting off the right.

Just like the seesaw explained above, when one of the transistors is working, the other is not, and the reverse action is made whenever a signal (pulse) is fed into the circuit. That is, the left-hand side of the seesaw corresponds to the Q1 while the right-hand to the Q2. The rolling ball represents the energy applied—which is the signal. This ball can roll by itself or by force exerted from outside (signal). Such a circuit is called the " Multivibrator ".

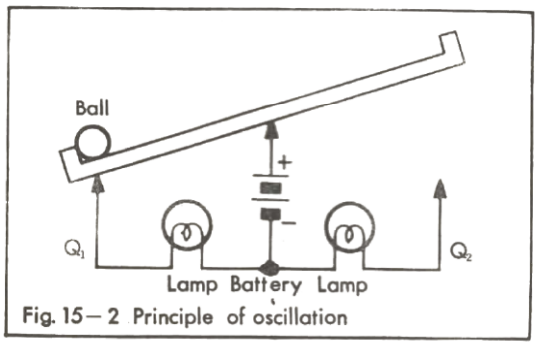


Fig. 15—2 Principle of oscillation

The transistors used in this kit are PNP type, so, (a) if a positive voltage (+) is applied to the Base, it will block the flow of current—the circuit is turned " OFF " and (b) if 0 volt or negative voltage (−) is applied to the Base, current will flow through the transistor—the circuit is " ON ".

Assuming that the internal resistance of the transistor is 0, the following voltage will be applied:

	Q1 "ON"	Q2 "OFF"
Base	0 Volt	+1.5 Volts
Collector	0 Volt	−1.5 Volts

and the C3 will be charged. This voltage will he discharged through the R2 of the Q2 until it is completely discharged to become 0 Volt, when the action (b) mentioned aboue comes into the picture—the Q2 suddenly becomes operational—or status "ON". The Collector voltage of the Q2 shifts from −1.5 Volts to 0 Volt, and this variation of voltage changes the C2, so the Base voltage of the Q1 shifts from 0 Volt to +1.5 volts. That is,

	Q1 "OFF"	Q2 "ON"
Base	+1.5 Volts	0 Volt
Collector	−1.5 Volts	0 Volt

Therefore, the switching is performed by the charging and discharging actions of 2 sets of capacitors and resistors connected to the Bases. The "ON" and "OFF" cycle of this circuit is expressed by the following equation:

$$T\ (\text{cycle}) = t_1 + t_2 \fallingdotseq 0.7\ (C_1RB_1 + C_2RB_2)$$

In order to produce a rectangular wave, $C_1 = C_2$, $RB_1 = RB_2$ and it is required that the value of capacitors and resistors connected to the Q1 and the Q2 have to be equal.

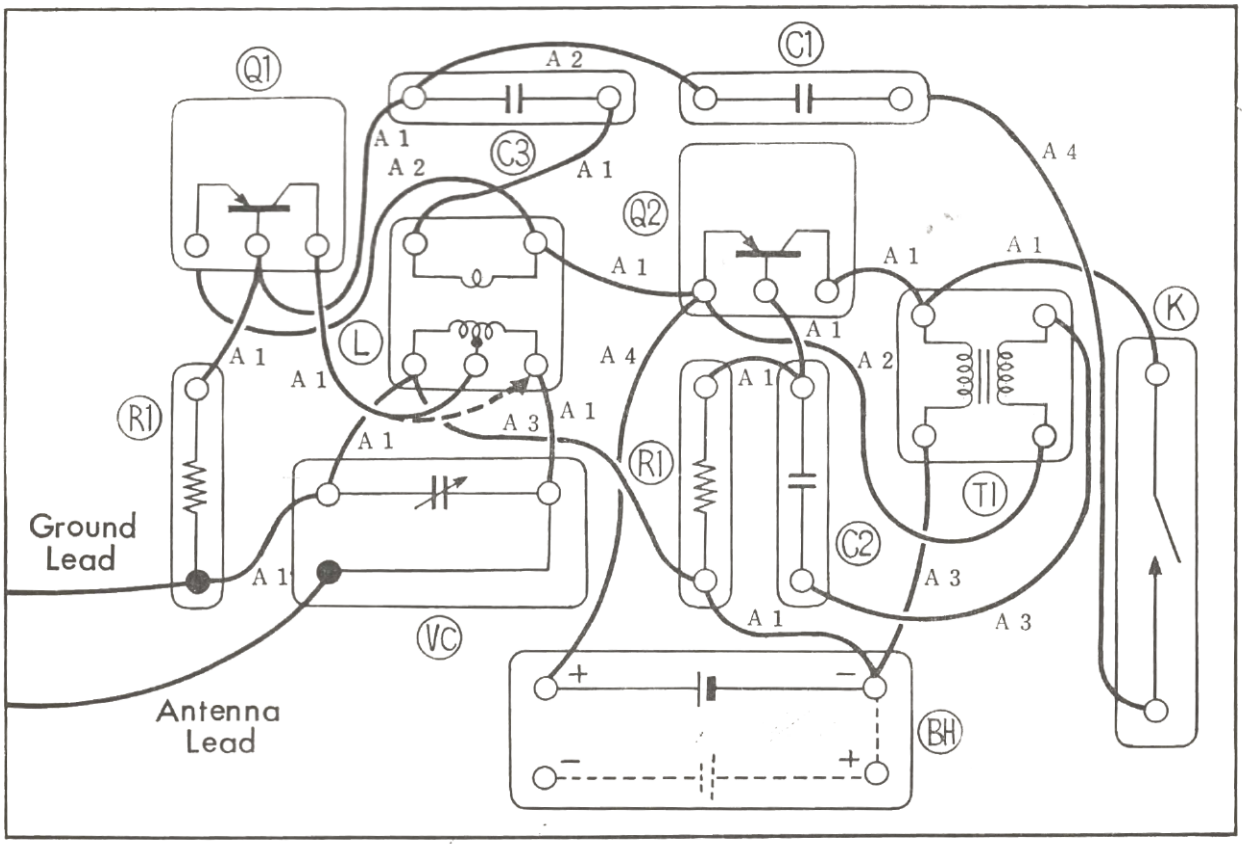
HOW TO USE "SOLAR CELL"

Please refer to "COMPLETE PARTS LIST FOR DIFFERENT PROJECTS" attached to the frontispiece, therein you will find that the projects where Solar Cell can be used are marked ○.

In this Kit, the Solar Cell can be applied to the circuits for Radios & Amplifiers and cannot be applied to the circuits for Oscillators, especially, High Frequency Oscillators. The reason is that the Solar Cell included in this Kit produces voltage of 0.5 V when it is exposed to the sunshine and it is therefore not suitable for the ocillating circuits that work well on high voltage.

When you wish to use the above Cell, it is necessary to remove Battery Holder #BH from the Circuit Mounting Board and place the Cell instead of Dry Battery. Be sure to connect Leads to the proper pin-terminal on the positive (+) used by Red lead and on the negative (−) used by Black lead.

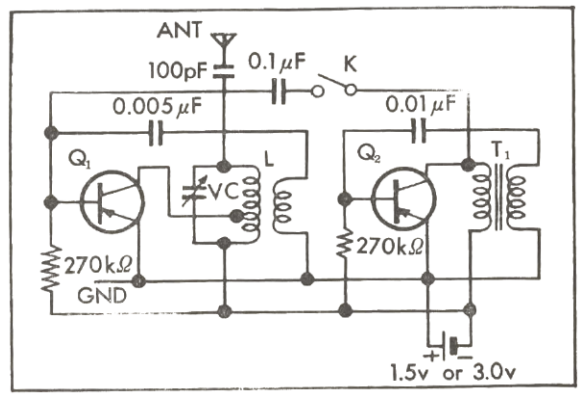
At the bright window in clear days, the Solar Cell will produce the voltage of 0.5 V and radio will work well. However, in cloudy days or under electric light, it will not produce enough voltage because of a shortage of light.



1. GENERAL DESCRIPTION

Radio wave type A2: A of the figure "A2" signifies the type of modulation and stands for "Amplitude". 2 of the "A2" denotes the type in which the Carrier Wave is carried, and this "2" stands for audio frequency signal put on and off by means of a telegraph key. A2 type radio wave is also called Modulated Telegraph. Since it is amplitude modulation, you can receive it by ordinary radio set.

Many nations in the world broadcast what is known as the standard frequency, serving the purposes for checking and alignment of radio equipments as well as informing the correct time. The Standard Frequency Stations in the world are listed in page 38.



If you are within the service area where such transmission can be heard, you can use the short wave receiver kit, assembled under the Project #12. Dial the Variable Tuning Capacitor slowly,

you will hear a whistling tone (1,000 cycle tone). In many cases, the whistling tone, interrupted by 1 second intervals, is the time signal. This time signal is the Standard Frequency, which frequency is precisely 5,000 kc (5 Mc) and the carrier wave is modulated with 1,000 cycle audio frequency. This is the typical A2 radio wave.

LIST OF STANDARD FREQUENCY STATIONS

Country	City	Call Letters	Frequency (kc)
Argentine	Buenos Aires	LOL	5,000*
〃	〃 〃	〃	10,000
〃	〃 〃	〃	15,000
Canada	Ottawa	CHU	3,330
〃	〃	(Time signal only)	7,335
〃	〃		14,670
Great Britain	Teddington	MSF	2,500
〃 〃	〃	〃	5,000*
〃 〃	〃	〃	10,000
Japan	Tokyo	JJY	2,500
〃	〃	〃	5,000*
〃	〃	〃	10,000
〃	〃	〃	15,000
South Africa	Johannesburg	ZUO	5,000*
〃 〃	〃	〃	10,000*
Switzerland	Neuchatel	HBN	2,500
〃	〃	〃	5,000*
U.S.A.	Lanham	WWV	2,500
〃	Washington D.C.	〃	5,000*
〃	Puunene, Hawaii	WWVH	5,000*
〃	Lanham	WWV	10,000
〃	Puunene, Hawaii	WWVH	10,000
〃	Washington D.C.	WWV	15,000
〃	Puunene, Hawaii	WWVH	15,000
〃	Lanham	WWV	20,000

Note: * indicates the standard frequency tunable with the Project #12 short wave receiver.

2. OPERATION AND CIRCUIT DESCRIPTION

Let us experiment with the completed set you have assembled. The left-hand side of Figure 16-1 is the A2 oscillator. The Q1 is the radio frequency oscillator producing the medium wave frequency. The Q2 is an audio frequency oscillator which is controlled by the Key #K to start and stop the oscillation. As a battery is inserted, the set goes into operation, radiating carrier wave from the antenna, and as the key is pressed down, radio wave is modulated by an audio frequency

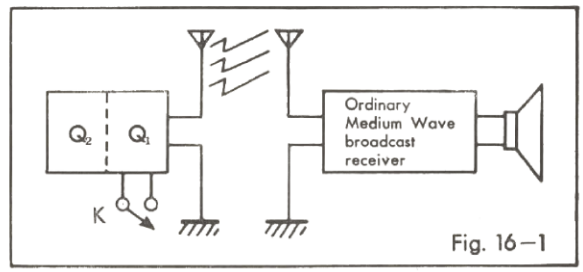


Fig. 16-1

and radiates into the air. The right-hand side of Figure 16-1 is an ordinary medium wave broadcast receiver. The A2 radio wave radiated from the kit is picked up by the receiving antenna and fed through the tuning, amplification and detector stages, and finally an audio frequency sound is reproduced from the speaker.

Let's study its practical application. Prepare a regular medium wave broadcast receiver. Since better reception can be received if the antenna is longer, it would be better to attach such an antenna lead to the set. Turn on the receiver's switch, make the volume higher and set the dial where no broadcast is heard. Next, insert a battery into the kit and draw the antenna of the kit close to the receiver, and press the key down and turn the Variable Tuning Capacitor slowly until the sound from the receiver will become the loudest. This is where both frequencies of the kit and the receiver should be matched. If you hear the sound too loud, you may keep away the antenna of the kit from the receiver or lower the volume of this receiver. The tone of audio frequency can be regulated by inserting the C1 across the secondary winding of the T1. This set can be used for practising the Morse Code likewise in the Project #14. A loud sound can be heard if through speaker, which will enable a group to have enough practice of the Morse Code.

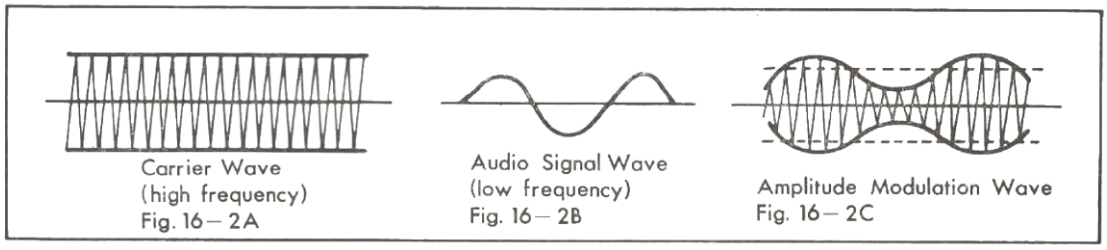
3. ABOUT MODULATION

Putting voice or audio frequency on top of a high frequency is called Modulation. There are dif.erent types of modulation, such as Amplitude Modulation, Frequency Modulation, Pulse Modulation, and so forth, but we shall discuss only on the Amplitude Modulation which this kit handles.

Figure 16-2A is the wave shape of oscillation produced by the Q1 Oscillator (Hartley type). The high frequency wave, which is not modulated, has a uniform width as shown in the Figure 16-2A. Since it can carry low (audio) frequency wave, it is also called a Carrier Wave.

Figure 16-2B is the wave shape of the Q2 Oscillator, and since it is a low (audio) frequency, its output can be heard with earphone.

Figure 16-2C is the wave shape when the low (audio) frequency is put on top (modulated) of the carrier wave, and such method of deforming the carrier wave with voice or low frequency is called the Amplitude Modulation.

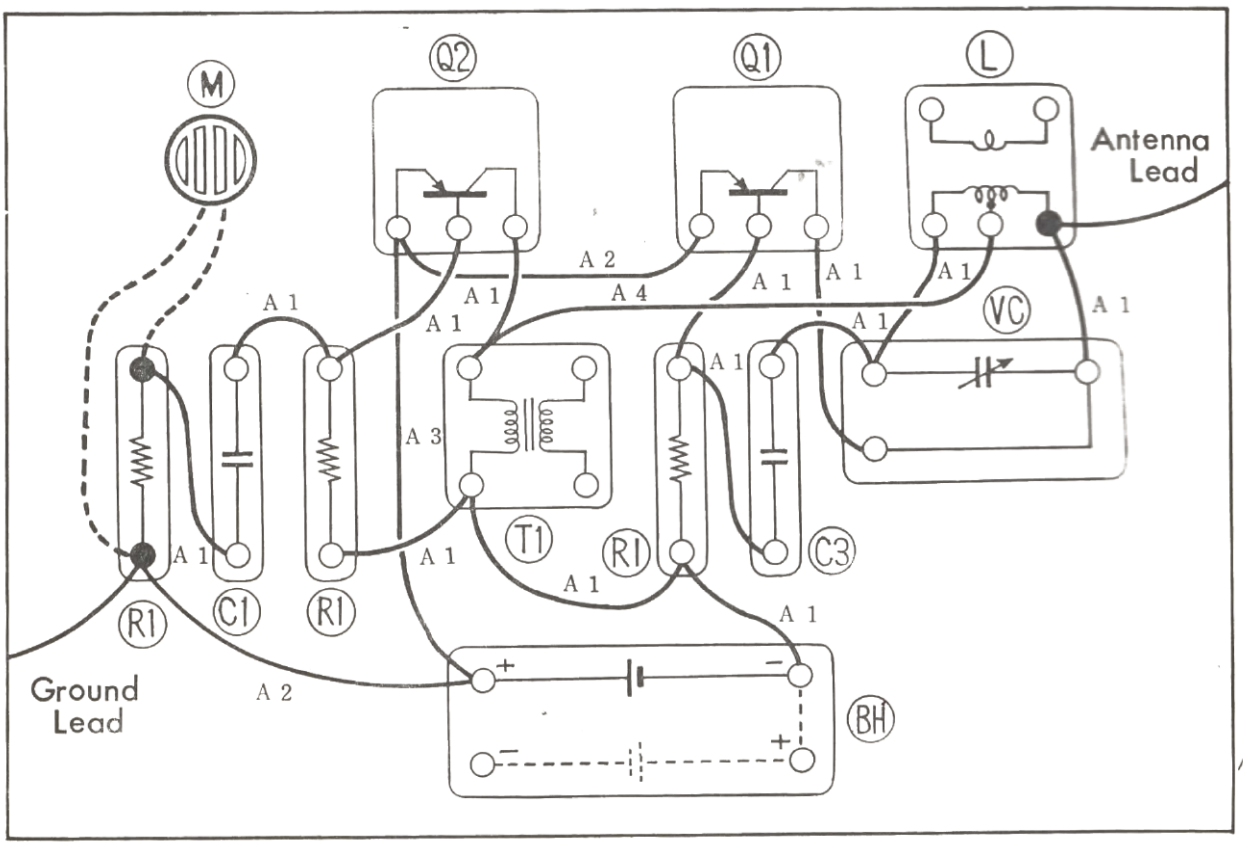


Carrier Wave
(high frequency)
Fig. 16－2A

Audio Signal Wave
(low frequency)
Fig. 16－2B

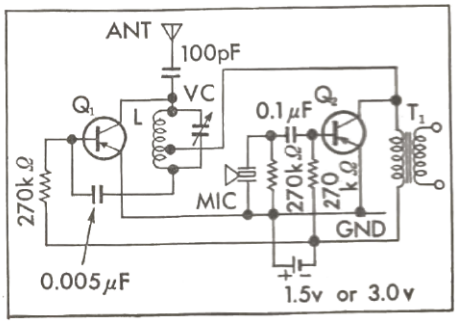
Amplitude Modulation Wave
Fig. 16－2C

PROJECT #17 for Assembling Wireless Microphone



1. GENERAL DESCRIPTION

Wireless Microphone is a wireless speech transmitter, in other words, a device for sending voice through the medium of radio wave—a miniature broadcasting station. As it is called so, this system does not require a microphone cable. It is convenient to use it on the stage when the singer sings in moving around and also when the radio reporter collects opinions of spectators in a stadium or various informations in a crowd. This system is also used for so-called "Eavesdropper". However, these microphones used for the above practical purposes are Frequency Modulated. When a record-player is connected instead of a microphone, it is called "Wireless-player".



To go on the air, you are required to get a licence, but the law permits to use equipment which radiates weak signal below a certain value stipulated by the law (this set is within legal limit).

2. OPERATION

Prepare a medium wave broadcast receiver. Turn on the switch, make the volume higher and set the dial where no broadcast is heard. Insert a battery into the kit, and draw the antenna close to the radio receiver. Turn the Variable Tuning Capacitor slowly while talking into the microphone, and stop when you hear a loud voice of your own from the radio set. This is the point where both frequencies of the kit and the radio receiver coincide. Leave the Variable Tuning Capacitor as it is, and move the kit away a little and speak into the microphone, because if they are put too close each other, "howling" or "feed-back" will occur. In such a case, it is advisable to turn the volume of radio down or move the microphone away from the radio.

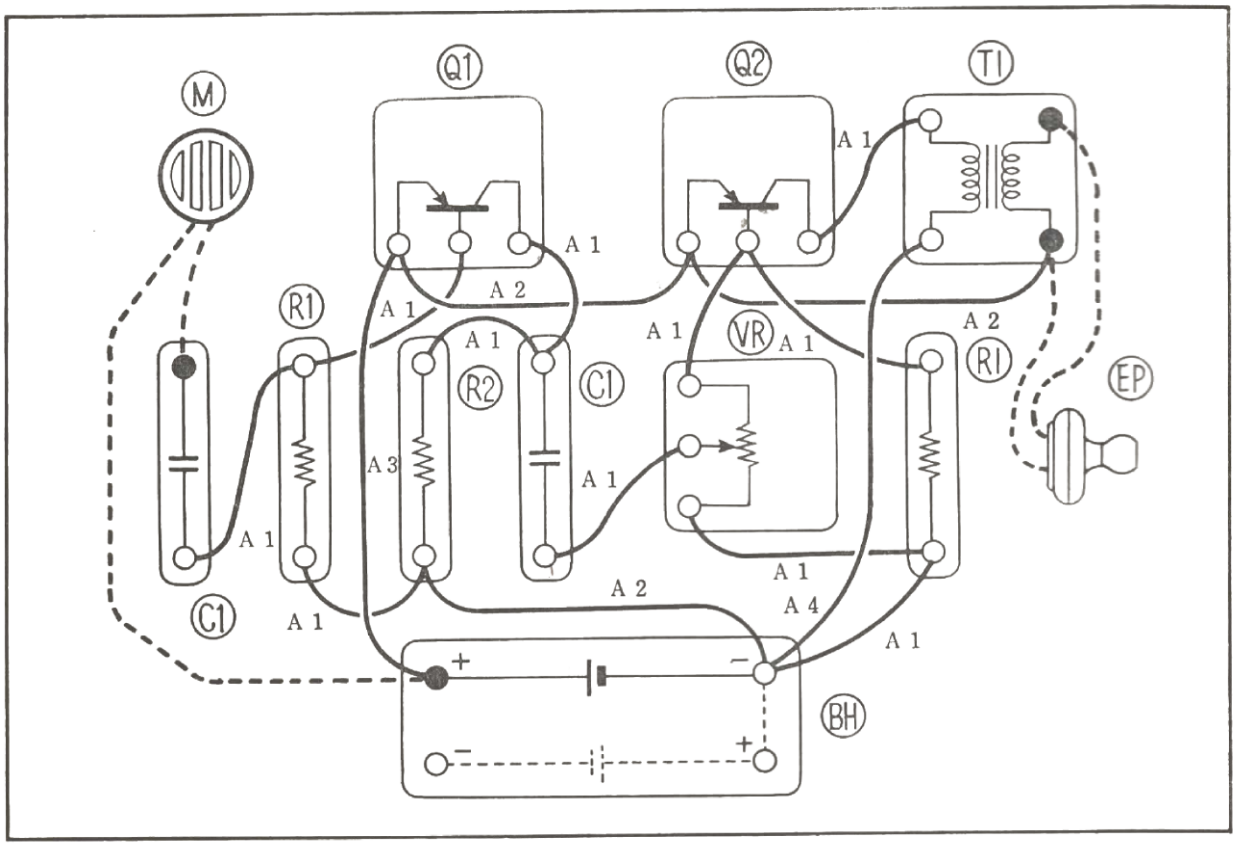
The practical distance of this set depends upon the sensitivity of the radio receiver and the length of antenna.

3. CIRCUIT DESCRIPTION

This set consists of a Hartley Oscillator for producing the Carrier Wave and an Audio Oscillator (it is called a Modulator for this case). The type of modulation is Amplitude Modulation (AM) for transmitting voice and music, so the radio wave transmitted from this set is type A2 radio wave.

The voice current from the microphone is applied through the C1 to the Base of Modulator Q2, and the amplified Collector Current varies in accordance with the input current. But the primary winding of the audio frequency transformer #T1 which has a high resistance to audio frequency is acting as a load to the Collector, so the increase of Collector Current of the Modulator Q2 cannot be derived from the power supply and it has to be derived from the current flowing to the Q1. In other words, when the Collector Current of the Modulator Q2 increases, the current of the Oscillator Q1 decreases, and the Collector Currents of the Q2 and the Q1 operate on opposite phases. Thus, the amplitude of the Carrier Wave is varied according to the modulation.

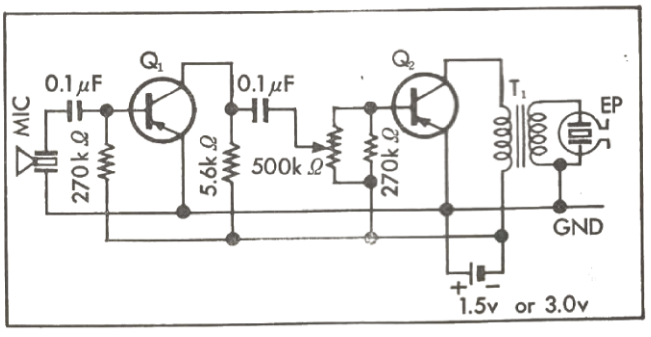
The method applied here is called the Heising Modulation and is frequently used in compact transceivers because the circuit is simple.



1. GENERAL DESCRIPTION

This is a simple communication system using an audio amplifier, in which a microphone plays the role of picking up sound and converts it into electrical energy which is then fed into an audio amplifier so as to boost the energy and reproduce it into sound again through earphone.

A real Intercom uses 2 speakers as transmitter and receiver instead of microphone and earphone as used in this Project. Voice picked up by one of the speakers is boosted when passing through the amplifier and activates the other speaker. So in a practical set, the function of each speaker is changed from transmitter to receiver and vice versa by means of switch so that conversation from both sides is possible. But in this project, one can only talk, while other listening.



Let's explain the reason why the speaker can be used instead of the

microphone. When an audio current flows through the voice coil of the speaker suspended in a strong magnetic field, the voice coil moves according to the variation of the current and activates the speaker's diaphragm. If this is done in the opposite way, sound can be converted into electricity. That is, when the sound pressure vibrates the diaphragm, the voice coil located within the magnetic field will move and then develop electromotive force in the coil corresponding with the movement of the coil. To utilize the induced current in the coil most efficiently, both ends of the coil should be connected to a matching transformer. A dynamic microphone is built under the same principle.

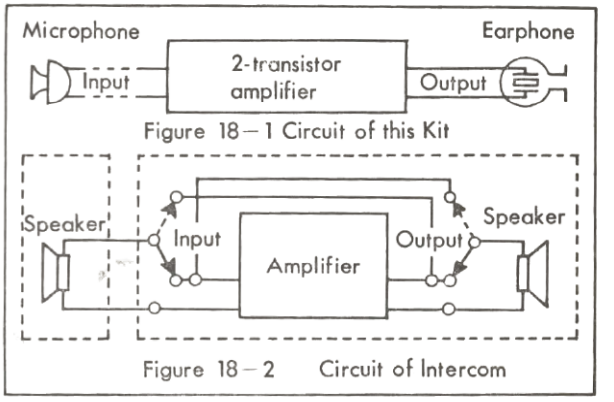


Figure 18－1 Circuit of this Kit

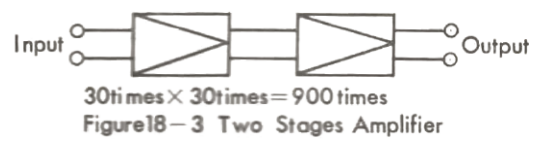
Figure 18－2 Circuit of Intercom

Figures 18-1 & 18-2 will help you to find how the connection is made when the Intercom is in "talk" or in "Listen" mode. The circuit of this Project is not provided with the switch for "talk" and "listen", and you can only talk from one side and listen at the other. It can be properly said to be a hearing aid.

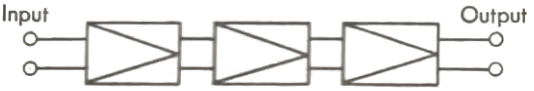
You can use this set for talking to a person in isolated room, for monitoring the room where a baby is sleeping, for talking in a noisy place and for many other interesting applications.

2. CIRCUIT DESCRIPTION

The sound coming into the amplifier is picked up by the crystal microphone. The structure of this microphone is similar to that of the crystal earphone which you have been using in this kit, but performs exactly the opposite function. As for the earphone, the variation of electric current, through the piezo-electric effect on Rochelle-Salt, is converted into mechanical vibration which produces sound. But crystal microphone converts sound into electric current. And this electric current (signal) flows through the C1 and is fed to the Q1 where the 1st stage amplification is performed. The signal amplified at the 1st stage flows through the coupling capacitor C1 (0.1μF) into the Variable Resistor #VR (Volume Control) where it is adjusted to the suitable loudness. Then it is fed into the 2nd amplifier stage—the Q2 circuit—where the doubly amplified signal activates the earphone.



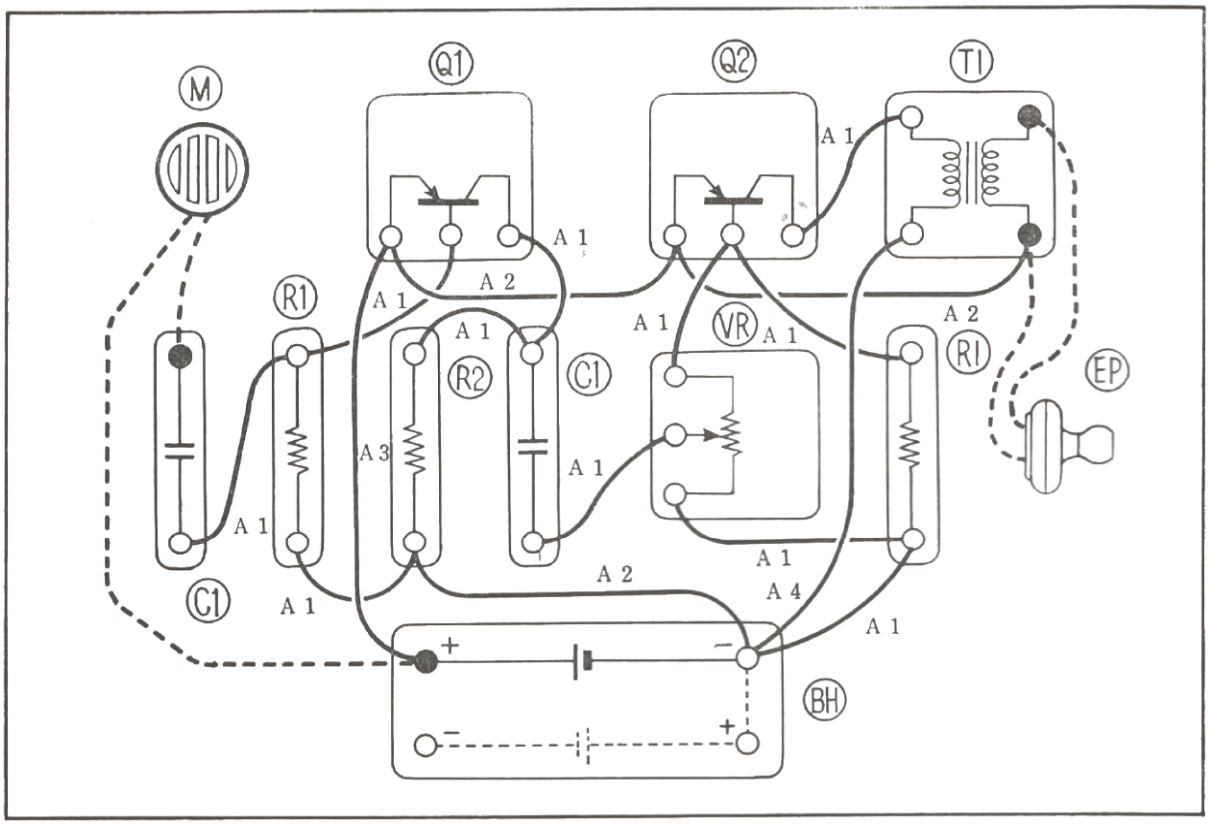
30times × 30times = 900times
Figure18－3 Two Stages Amplifier



30times × 30times × 30times = 27,000times
Figure 18－4 Three Stages Amplifier

When amplifiers are connected one after another as such, the total amplification becomes very high as shown in Figure 18-3 & 18-4, and even very weak signal can be amplified to an usable level.

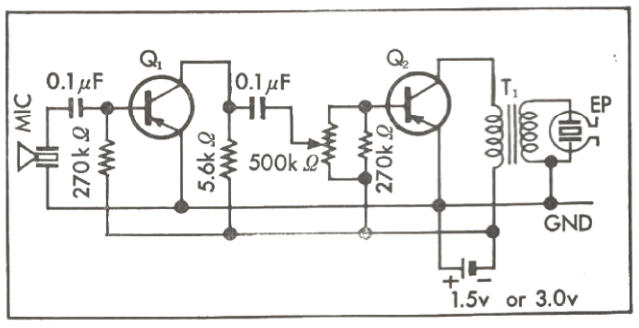
PROJECT #18 for Assembling 2-Transistor Intercom



1. GENERAL DESCRIPTION

This is a simple communication system using an audio amplifier, in which a microphone plays the role of picking up sound and converts it into electrical energy which is then fed into an audio amplifier so as to boost the energy and reproduce it into sound again through earphone.

A real Intercom uses 2 speakers as transmitter and receiver instead of microphone and earphone as used in this Project. Voice picked up by one of the speakers is boosted when passing through the amplifier and activates the other speaker. So in a practical set, the function of each speaker is changed from transmitter to receiver and vice versa by means of switch so that conversation from both sides is possible. But in this project, one can only talk, while other listening.



Let's explain the reason why the speaker can be used instead of the

microphone. When an audio current flows through the voice coil of the speaker suspended in a strong magnetic field, the voice coil moves according to the variation of the current and activates the speaker's diaphragm. If this is done in the opposite way, sound can be converted into electricity. That is, when the sound pressure vibrates the diaphragm, the voice coil located within the magnetic field will move and then develop electromotive force in the coil corresponding with the movement of the coil. To utilize the induced current in the coil most efficiently, both ends of the coil should be connected to a matching transformer. A dynamic microphone is built under the same principle.

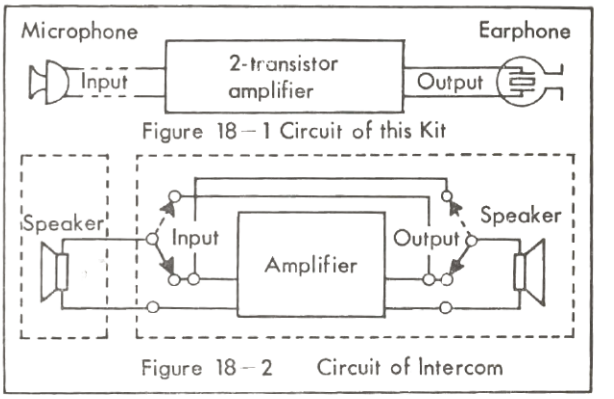


Figure 18－1 Circuit of this Kit

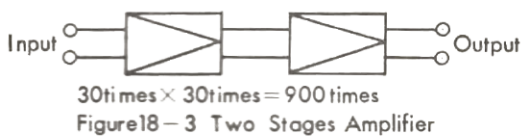
Figure 18－2 Circuit of Intercom

Figures 18-1 & 18-2 will help you to find how the connection is made when the Intercom is in "talk" or in "Listen" mode. The circuit of this Project is not provided with the switch for "talk" and "listen", and you can only talk from one side and listen at the other. It can be properly said to be a hearing aid.

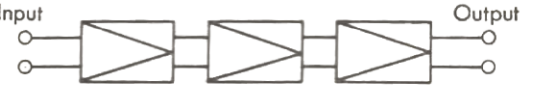
You can use this set for talking to a person in isolated room, for monitoring the room where a baby is sleeping, for talking in a noisy place and for many other interesting applications.

2. CIRCUIT DESCRIPTION

The sound coming into the amplifier is picked up by the crystal microphone. The structure of this microphone is similar to that of the crystal earphone which you have been using in this kit, but performs exactly the opposite function. As for the earphone, the variation of electric current, through the piezo-electric effect on Rochelle-Salt, is converted into mechanical vibration which produces sound. But crystal microphone converts sound into electric current. And this electric current (signal) flows through the C1 and is fed to the Q1 where the 1st stage amplification is performed. The signal amplified at the 1st stage flows through the coupling capacitor C1 (0.1μF) into the Variable Resistor #VR (Volume Control) where it is adjusted to the suitable loudness. Then it is fed into the 2nd amplifier stage—the Q2 circuit—where the doubly amplified signal activates the earphone.



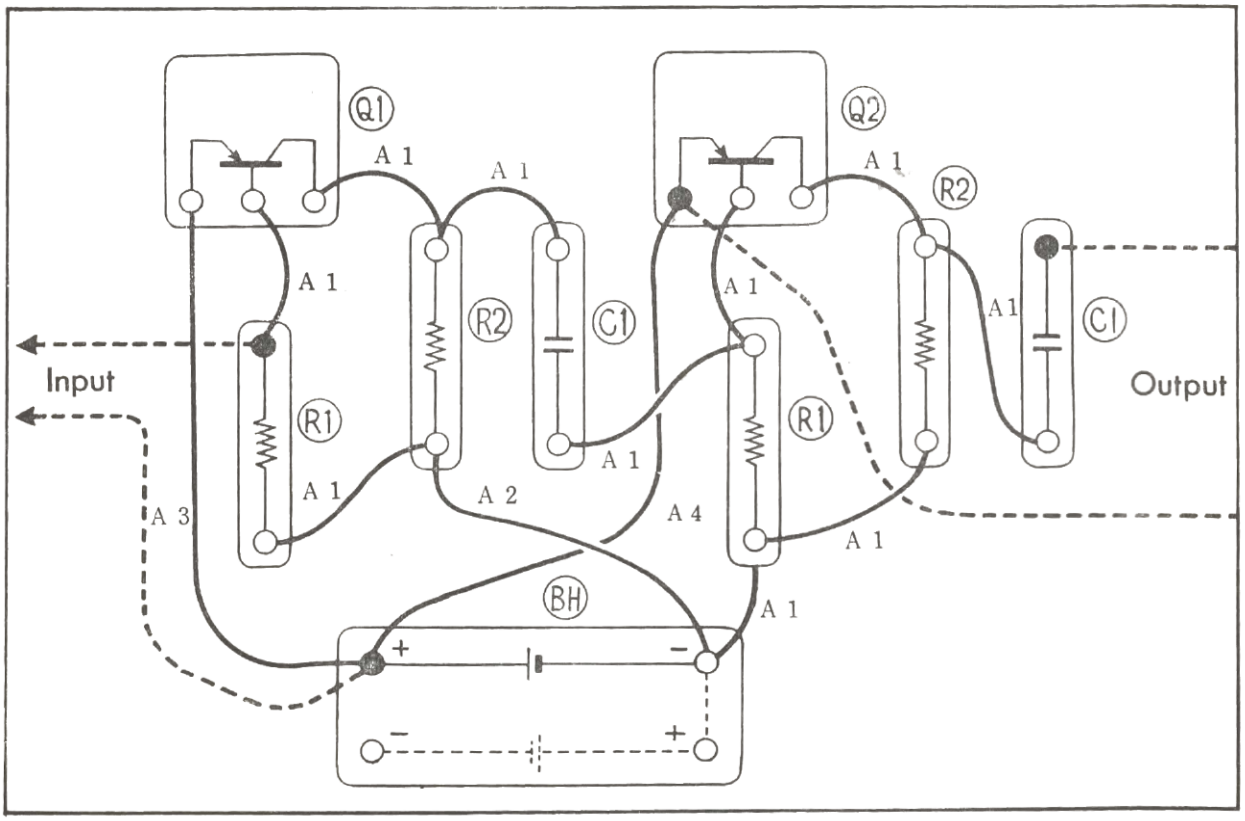
30times × 30times = 900 times
Figure18－3 Two Stages Amplifier



30times × 30times × 30times = 27,000times
Figure 18－4 Three Stages Amplifier

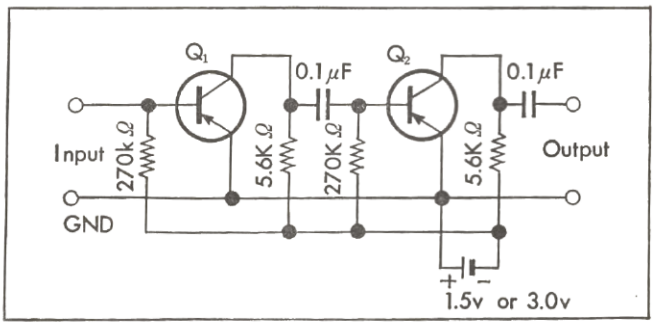
When amplifiers are connected one after another as such, the total amplification becomes very high as shown in Figure 18-3 & 18-4, and even very weak signal can be amplified to an usable level.

PROJECT #19 for Assembling 2-Transistor Audio Frequency Amplifier



1. GENERAL DESCRIPTION

Amplification means to enlarge the amplitude of a signal, and Amplifier is the device for performing such a function. In other words, if a signal of small amplitude is fed into the input terminal and is passed through the amplifier, a signal of large amplitude will appear from the output terminal of the amplifier. But this does not mean that the input signal with small amplitude itself is enlarged by the system; it is considered that the original signal is transformed into another signal with a larger amplitude through the function of transistor, which is just like the difference between the enlarged photo from a small photo and the enlarged diagram by means of Diagraph. Audio amplifier is most widely used and important because it is the basis of all amplifier circuits.



The structure of this amplifier is called the Resistance Coupled Amplifier, and as shown in Figure

19-2, a resistor is used as a load for the Collector and a capacitor is used for coupling with the following stage, so precisely it should be called the Resistance-Capacity Coupled Amplifier (R-C Coupled Amplifier). As for the coupling of amplifier, besides this, there are Transformer Coupling, Choke Coupling and Direct Coupling Methods. Amplifiers are sometimes classified into High Gain Preamplifier for amplifying weak signal and Power Amplifier for producing large output, according to the usage. Because this circuit is a Preamplifier for amplifying weak signals, consisting of two stages of grounded emitter amplifiers providing high amplification, it is suitable for amplifying an extremely weak signal to be fed to subsequent stages.

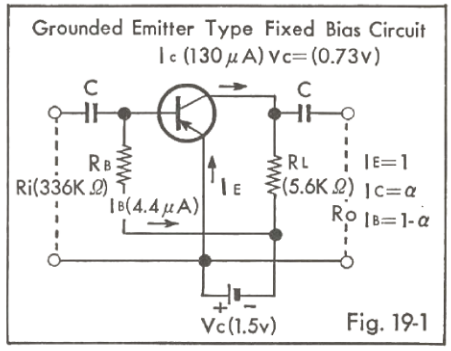


Fig. 19-1

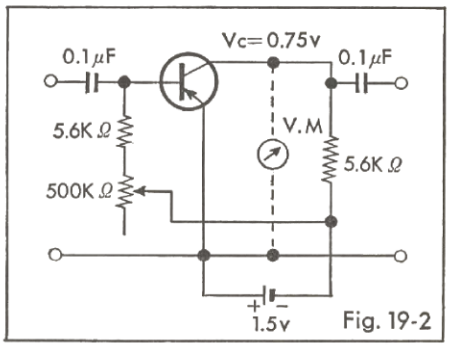


Fig. 19-2

2. CIRCUIT DESCRIPTION

Our daily speech contains such a frequency within the ranges of 200 to 1,000 cycles approximately, and suppose you are to amplify human voices, it would be sufficient if the amplifier is capable of amplifying sound within the ranges. However, if you are to listen to music, the amplifier should be capable of amplifying such from as low as 20 cycles and as high as to 10,000 cycles or more in a uniform manner.

In addition to this, the signal wave shape of the sound applied to the input has to be amplified faithfully and without any distortion, and yet the capability of amplifying the input signal has to be as large as possible.

These are the 3 important points by which you can decide whether an amplifier is good or bad. Now we will look into the bias situations which has relations to distortion and amplification—the most important factor of all.

Fig. 19-1 is the circuit assembled under the Project #8 which is a Grounded Emitter Amplifier. The C1 is a Coupling Capacitor to conduct the input signal in and at the same time to block direct current.

R_L is the load resistor for the Collector, and although it differs according to the usage, it is usually between 1 kilo ohm and 50 kilo ohm.

R_B is the Base Bias Resistor which governs the function of this circuit. The input signal is applied over this bias and its current swings to both sides of this bias. The Collector Current varies accordingly, but in a larger magnitude.

There is one condition to follow in designing this Resistance Coupled Amplifier.

That is, $Vc \fallingdotseq Vcc/2$, meaning that the Collector Voltage should be approximately one half of the Power Supply Voltage. If it is set up this way, it will allow the Collector Voltage to swing fully centered on this point so that the maximum output can be obtained. Naturally, the value of the resistor to supply the Base Bias is calculated so as to make the Collector Voltage half the Power Supply Voltage. It is expressed by the following equation:

$$R_B = 2R_L\beta$$

In order to verify the above, experimental circuit as the Fig. 19–2 is set up. A volt meter is connected to the Collector, and the Variable Resistor VR (500 kilo ohm) is adjusted so as to make the volt meter half the Supplied Voltage (1.5 V).

Note: In this case, the volt meter should be of high internal resistance.

Formulas for Grounded Emitter Resistance Coupled Amplifier will be given next, and necessary values for the amplifier can be calculated from this.

Calculation using parameters:

Formulas:

Collector Current $I_c = \dfrac{Vcc}{2R_L}$

Base Current $I_B = \dfrac{Vcc}{2R_L\beta}$

Base Resistance $R_B = 2R_L\beta$

Input Resistance $R_i = \dfrac{R_L}{1-\alpha} = (1+\beta)R_L$

Voltage Amplification $Av = \dfrac{\beta R_L}{rb+(1+\beta)re}$

Power Gain $PG = \beta Av$

Condition: $Vcc \leqq Vc$ max $Vc \fallingdotseq Vcc/2$

Characteristic (r Parameter):

Emitter Resistance: re

Base Resistance: rb

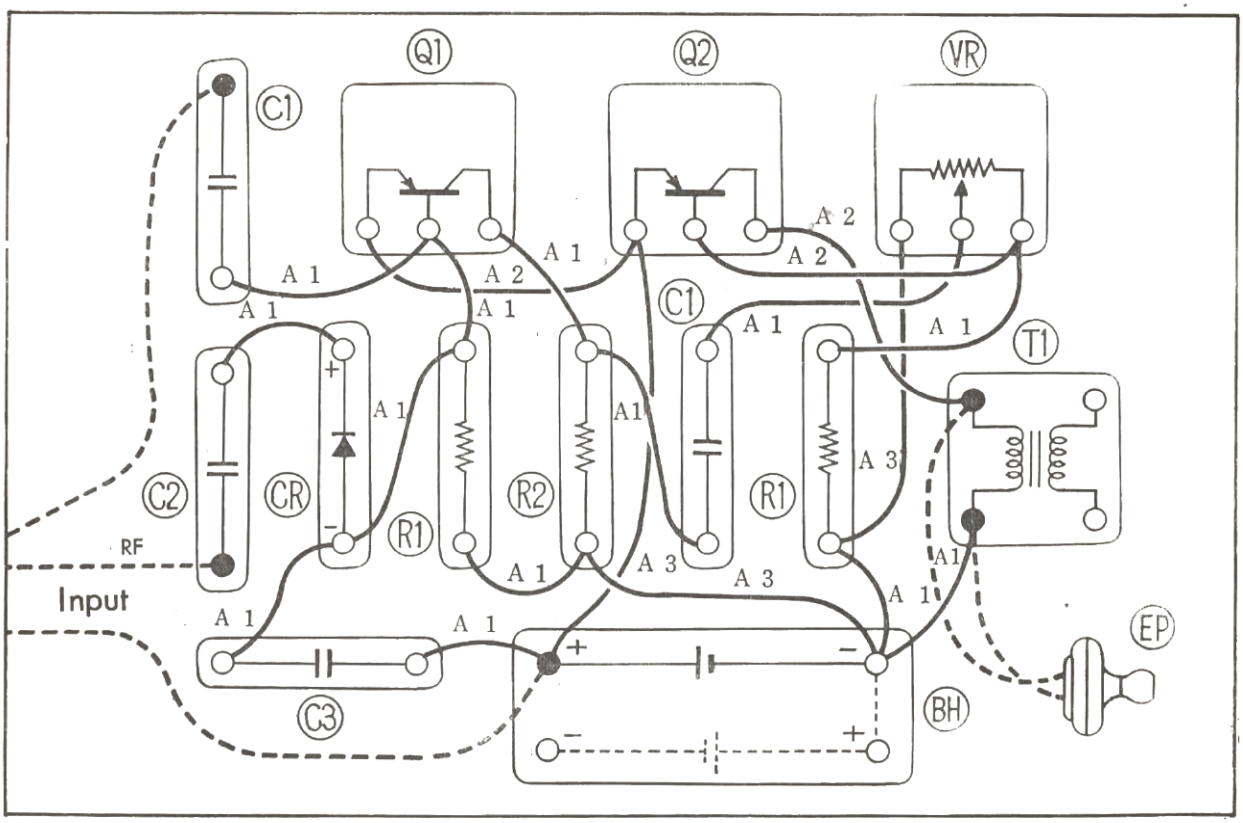
Collector Resistance: rc

Current Amplification: α

Current Amplification: β

Load Resistance: R_L

Supplied Voltage: Vcc



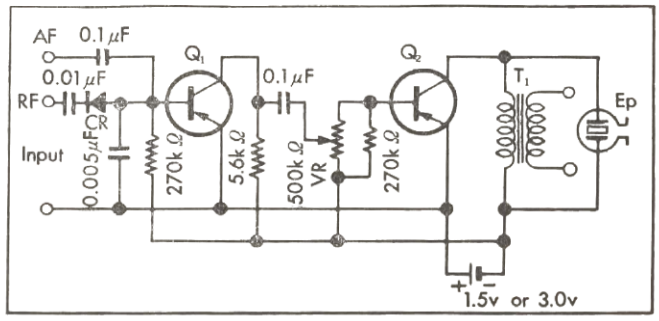
1. GENERAL DESCRIPTION

"Signal" mentioned in radio sets and amplifier is either radio wave or audio frequency, and it is the role of the Signal Tracer to check the existence of such signal in the circuit.

When a radio set is out of order or not working well, use the Signal Tracer to locate the point where the signal is coming through and where it disappears. This will enable you to decide whether the detector circuit is bad or amplifier stage is not functioning so as to find out the source of the trouble.

2. CIRCUIT DESCRIPTION AND OPERATION

The input terminal with a 0.1μF Capacitor #C1 (abbreviated to AF) is for Audio frequency, and the one with a capacitor and a Germanium Diode (abbreviated to RF) is for high frequency use. The ground is used in common for both cases. If you hear something from the earphone



that is the sign there is a signal, and if you don't hear anything, there is no signal. Operation of the Signal Tracer is explained as follows as example of the Germanium Diode 1-Transistor Radio under the Project #5.

Put the radio set in operation and connect the ground terminal of the Signal Tracer to the ground of the radio set. First, to start from the RF input, touch the junction of the Variable Tuning Capacitor and the antenna of the radio set, stator of the Variable Tuning Capacitor (pin at right) or the Tuning Coil (pin at lower right) with the RF. The Variable Tuning Capacitor of the radio is turned, and if a signal is heard after being detected by the Germanium Diode of the Signal Tracer this radio is good up to this point. If you get a crackling noise or don't hear anything at all, the trouble is assumed that short circuit has been caused between the plates of the Variable Tuning Capacitor or wire in the coil has been broken. If you have checked from antenna to detector circuit and proved them O.K., the radio is no doubt properly functioning up to the input of Germanium Diode, so the input AF of the Signal Tracer will be used to check from the Diode to the transistor amplifier circuit.

The reason for quitting the RF and switching to the AF is because there will be signal after the detector. What exists between the antenna and the input of detector is the radio wave called "High Frequency" and when the Signal Tracer deals with such signal, it detects and amplifies the signal and reproduces in form of sound to verify the existence of high frequency signal, therefore the RF input is used. Because signal existing after the detector is audio signal, it is fed directly into the amplifier stage of the Signal Tracer to trace it, so the input AF is used.

If the output of the detector or the positive (+) side of the Germanium Diode is touched by the input AF of the Signal Tracer, broadcast will be heard so long as the detector is good. If nothing is heard, it is probably due to the defect of the Germanium Diode. In this case, if broadcast is heard by touching with the input RF, it is definite that the detector is defective.

As explained above, Signal Tracer can check the operating condition of radio sets by replacing parts and circuit; it is very important to select in using the right input, whether the RF or the AF. Please bear in mind that the RF is for High (Radio) Frequency and the AF is for Audio (low) Frequency.

Now, after checking the audio signal coming out of the Germanium Diode, the next step is to touch the AF on the junction point of the Capacitor #C1 and the Base of the Q2. If the sound is weaker here than at the output of the diode #CR, you will find that the capacitance of the C1 has been decreased. If nothing can be heard, you will know that it is either the capacitor has lost its capacitance or the lead wire has been broken inside. If the capacitor is normal, it should sound the same at the output of the Germanium Diode.

Then, touch the AF on the Collector of the Transistor #Q2. It should sound louder here because the signal is amplified by the transistor. If the sound is not louder or rather weak, you will find that the Transistor #Q2 is defective or the circuit components

have problems, such as the wire of Resistor or Capacitor has been broken or Capacitance has been decreased.

Now again, let us look at the Signal Tracer from a different angle. It is understood that Signal Tracer, known by its term, traces the signal from antenna to earphone (or speaker), in other words, from the entry of radio wave down to its exit. Since Signal Tracer is composed of a Detector and an Amplifier, Germanium Detected 2-Transistor Radio can be formed by providing an antenna and a tuning circuit connecting to the RF input. If the low output Germanium radio is connected to the AF, a radio with ample volume will be formed as the same one mentioned above. This is because the 2-Transistor amplifier stage is added to the Germanium radio.

Next, if a microphone is connected to the AF, it will become a low power wired telephone system. Talk into the microphone and listen with the earphone. If you extend the wire, it will be practical for an improvised telephone system.

There are many other applications to this Signal Tracer, so why not have something of yours. Test it on your home radio when being out of order. It is advisable for you to attach a test prod like the one used with the circuit tester to the inputs of the Signal Tracer when working on your home radio.

INTERNATIONAL MORSE CODE

In learning the code you should think it in term of language of sound, for instance, dot as "dit" and dash as "dah", thus sounding didah for "A" (– ——), dahdididit for "B" (—— – – –).

Other examples: Period: didahdidahdidah for – —— – —— – ——
Y: dahdidahdah for —— – —— ——
Q: dahdahdidah for —— —— – ——
(The "t" is dropped in combination)

A	—	S	· · ·
B	—— · · ·	T	—
C	—— · —— ·	U	· · ——
D	—— · ·	V	· · · ——
E	·	W	· —— ——
F	· · —— ·	X	—— · · ——
G	—— —— ·	Y	—— · —— ——
H	· · · ·	Z	—— —— · ·
I	· ·	1	· —— —— —— ——
J	· —— —— ——	2	· · —— —— ——
K	—— · ——	3	· · · —— ——
L	· —— · ·	4	· · · · ——
M	—— ——	5	· · · · ·
N	—— ·	6	—— · · · ·
O	—— —— ——	7	—— —— · · ·
P	· —— —— ·	8	—— —— —— · ·
Q	—— —— · ——	9	—— —— —— —— ·
R	· —— ·	0	—— —— —— —— ——